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A Summary of Current Program 7/1/66

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and Preliminary Report of Progress

for 7/1/65 to 6/30/66

ANIMAL HUSBANDRY RESEARCH DIVISION

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UNITED STATES DEPARTMENT OF AGRICULTURE

and related work of the

STATE AGRICULTURAL EXPERIMENT STATIONS

This progress report is primarily a tool for use of scientists and administrators in program coordination, development and evaluation; and for use of advisory committees in program review and development of recommendations for future research programs.

The summaries of progress on USDA and cooperative research include some tentative results that have not been tested sufficiently to justify general release. Such findings, when adequately confirmed, will be released promptly through established channels. Because of this, the report is not intended for publication and should not be referred to in literature citations. Copies are distributed only to members of Department staff, advisory committee members and others having a special interest in the development of public agricultural research programs.

This report includes a list of publications reporting results of USDA and cooperative research issued between July 1, 1965 and June 30, 1966. It also includes a list of related publications of State Experiment Stations for the same period. Current agricultural research findings are also published in the monthly USDA publication, Agricultural Research. This progress report was compiled in the Animal Husbandry Research Division, Agricultural Research Service, U. S. Department of Agriculture, Agricultural Research Center, Beltsville, Maryland.

UNITED STATES DEPARTMENT OF AGRICULTURE

Washington, D. C.

July 1, 1966





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## INTRODUCTION

Research in livestock production will benefit the public through lower-cost animal foods and an assured supply of high quality foods more suited to their needs. It assists individual farmers by lowering costs and increasing net income. It will also improve the utilization of the surplus grain supply. More efficient high producing animals of the various classes will aid the small farmer particularly, permitting a more diversified enterprise. They will strengthen rural area development programs by making livestock farming on a small-scale more attractive.

The mission of the Animal Husbandry Research Division is to conduct research which will reduce costs of animal production, provide the consumer with animal products of improved quality, and provide basic animal science information. As more of the simpler practical problems of animal production are solved, more complex problems must be attacked. For solving these complex problems basic information on the genetics, physiology, and nutrition of livestock is necessary. Even though such basic information is obtained in the Animal Husbandry Research Division by the majority of our scientists, increasing emphasis is placed upon basic research and studying problems in depth.

The investigations of the Animal Husbandry Research Division are carried out by a staff of approximately 500 persons, of whom about 160 are professional research scientists. The work is conducted at Beltsville and at field locations throughout the United States. Many of the projects are carried out cooperatively with State agricultural experiment stations, and some with other Federal agencies, other divisions in the Agricultural Research Service, and non-federal organizations. Investigations are carried on in various aspects of genetics and breeding, nutrition and feeding, feed composition and evaluation, anatomy, physiology, and management. National cooperative record of performance programs are conducted with dairy cattle and poultry. Research also is conducted on the quality of meat, milk and eggs, as influenced by production factors; on the control of avian leukosis in poultry; and on the basic metabolism in the animal body of pesticides, hormones, and other chemicals used in agricultural production and the effects of these chemicals on animal products.

As a step toward implementation of the recommendations for a National Program of Research for Agriculture made jointly by the Association of State Universities and Land Grant Colleges and the USDA, a section has been added to each of the Areas in this report. It comprises a list of the related publications of the State Agricultural Experiment Stations in addition to those heretofore reported covering the results of USDA and cooperative research. In future years, it is anticipated that information will be available to permit reporting of achievements resulting from State research in a format comparable to the present reporting of the USDA and cooperative research.



It is frequently costly and unwise to make extensive program shifts until a promising and worthwhile research project is completed. Furthermore, most animal husbandry investigations are necessarily long term in nature. Consequently, it is easy to lose sight of the degree to which progress has been made in a yearly published report such as this. A few of the more recent developments which have made marked contributions to the industry and/or to their research activities are mentioned briefly below.

Non-protein nitrogen utilization related to ruminal acids. Valine, isoleucine, leucine, and phenylalanine were detected in significantly smaller quantities in the blood plasma of steers fed urea rather than soy protein diets. Evidence indicates that the lack of sufficient quantities of the branched-chain volatile fatty acids at the ruminal level may have been responsible for the lowered plasma amino acid values. This information suggests why animals on diets containing 100% of their dietary nitrogen from non-protein nitrogen sources do not perform as well as animals on protein-containing diets. This knowledge could result in an improved utilization of non-protein nitrogen in ruminant diets.

Pesticide residues. An investigation into the distribution of DDT residues in the animal fat was completed. Thirteen body locations were represented by samples of caudal, cod, caul, ruffle, kidney, external rib, internal rib, heart, and brisket fat and muscle samples of round, rib-eye, diaphragm muscle, and psoas major. The distribution of DDT residues in the extractable fat among the samples varied and the residue content of caudal fat was most representative of the tissues studied. This indicates a very convenient technique with which to study the accumulation and dissipation of residues in beef animals and is being used in present residue studies.

Studies on feeding habits of beef cattle show lighted feedlots increase efficiency. Cows, steers, and heifers have been found to do about 25% of their feeding throughout the night, even without lights. However, continuous lighting results in more uniform spacing of time at the feeder during the 24-hour day. This may result in improved feed efficiency. Better management may also result from the finding that feedlot cattle feed 9 to 14 times daily and that they spend 20-30% less time at the feeder when rations are high in grain or pelleted or when in competition with other animals. These data were obtained with the use of an electric-eye beam, broken when the animal placed his head inside the feedbunk to eat, and the time and length of feeding registered on a data recording machine.

Dairy beef production. The great majority of male calves produced by over 17 million dairy cows in the United States are marketed as veal or "bob" veal (5-10 days of age) and therefore produce fewer pounds of human food than if they were fed out as beef and slaughtered at heavier market weights. If, as appears probable, human populations increase more rapidly than cattle numbers in the United States in future years, it may be advantageous to raise these calves to weights beyond the present veal limits. Our research indicates that large dairy breed steers will make

larger gains in body weight than beef steers. The beef steers had a higher carcass grade, but the dairy steers were higher in percent lean meat.

Fungicide found beneficial for improving the preservation of low-moisture silages. Exclusion of atmospheric oxygen is a fundamental requirement of all ensiling procedures. Because of its low density, low-moisture silage is particularly vulnerable to oxygen damage. Air reaching the surface of such silage penetrates quickly and deeply resulting in heating and molding. One fungicidal material (Mylone) provided marked and prolonged inhibition of heat and mold damage in silage under laboratory conditions. Field observations have shown similar benefits in poorly sealed or slowly fed stacks of low-moisture alfalfa silage and mature corn silage. The practice holds promise of considerable practical benefit, however, further research is needed regarding possible residues and definition of the conditions under which it will and will not provide a benefit.

Reduction of harvesting losses in forages with wilting. The net advantage of storing forage crops as wilted or low moisture silage depends to a large extent on the extent of field losses associated with wilting and harvesting. By use of an improved technique involving mowing and wind-rowing as a single operation, losses in alfalfa were only 3% as compared to 10-17% when mowing and raking was done separately. Rain damage increased the loss in the single operation to 12%. Under good weather conditions, the advantage of the combined operation included reduced labor requirements as well as an increased crop recovery.

Marek's Disease (Acute Leukosis) virus found in oral washings and feces. Poultrymen are experiencing heavy losses in growing chickens due to acute leukosis or Marek's Disease. This disease has been known to be highly contagious and spread from chicken to chicken. However, the primary sources of this infection were not known. Through research at the Regional Poultry Research Laboratory at East Lansing, it has been shown that saliva and feces are carriers of the virus and capable of transmitting the disease. Day-old chickens were exposed to fecal extracts and washings of the oral cavity of diseased chickens. All chickens inoculated with either of these materials by the intra-abdominal route developed the disease and all controls remained healthy. The more natural routes of exposure, such as nasal or oral application, resulted in a much lower rate of infection. These findings will be of great benefit to the poultry industry and should result in reduced losses due to this disease.

Electronic egg recorder used in recording egg production. An electronic digital recorder with the capacity to record the time of lay of up to 10,000 hens has been developed cooperatively by the Poultry Research Branch, AHRD, and the Farm Electrification Branch, AERD. This system records the time of lay of each egg, which allows for complete information on the ovulatory sequences of birds selected for egg production under both 18-hour "short days" and 24-hour normal days. Information obtained during both day and night is punched directly onto computer tape. This greatly reduces the work load of collecting these data and simplifies later



analysis of the information collected. This system will have considerable utility in research programs.

Method for the determination of tryptophan. A new method for analysis of the essential amino acid tryptophan was developed. This involved an original procedure for the quantitative recovery of the amino acid from alkaline hydrolysates and major modification in the ion-exchange chromatographic techniques. These developments made available for the first time a rapid method for direct and accurate determination of tryptophan in both pure and crude protein. This will provide a new analytical tool for the nutritionist engaged in amino acid research, the feed manufacturer in diet formulation, and also the clinical researcher, since the method can be readily applied to the analysis of body tissues and fluids.

Method for early diagnosis of pregnancy in sheep developed. Early diagnosis of pregnancy in sheep to permit proper feeding, rebreeding or culling has heretofore not been possible except with surgery. A highly accurate method using ultrasonics has been developed which permits diagnosis within 60 days following breeding or in the first two-fifths of gestation.

Estrus control in sheep found beneficial. Progestin, either injected or given orally, over a 12 to 14 day period is effective in synchronizing estrus so that a high proportion of ewes may be bred in a 2-4 day period. The ewes remain well synchronized for a second and even third estrous period. Fertility is higher at the second and third periods than at the first. Individual selected rams gave satisfactory fertility when mated to 60 synchronized ewes over a 2-4 day period. Thus, lambing may be concentrated over a short and predetermined period without reduction in number of ewes mated per ram. This aids in adopting more efficient management practices. This work was done at Dubois, Idaho, in cooperation with the Idaho Agricultural Experiment Station.

Type of pig influences use of feed in the production of fat and lean. Limited feeding improved the carcasses of pigs bred for high backfat but had little or no value in this respect for pigs bred for low backfat. Pigs from lines in two breeds selected over several generations for high and low backfat responded differently to limited feeding. Restriction of energy intake for high-fat pigs in both breeds reduced the pounds of fat but had no influence on the pounds of lean in the carcass at 220 days of age, while similar treatment for pigs in low-fat lines reduced the poundage of both fat and lean. Since selection in these lines was based entirely on backfat thickness attained at 175 pounds from full feeding, it is apparent that selection has been effective in developing strains of hogs that produce lean carcasses with full feeding. It is also apparent that the influence of limited feeding on carcass composition depends on the genetics of the pig for deposition of fat and lean tissue.

Method developed for reviving apparently stillborn pigs. A soft plastic funnel used for mouth-to-mouth resuscitation can restore life to pigs that apparently are stillborn. The method reduced stillbirth losses in the

herd at Miles City, Montana, by 6%. A polyethylene funnel is fitted tightly over the pig's nose and mouth. Air is then blown into the stem of the funnel and thus forced into the lungs of the pig. After several repetitions of the treatment, the pig will kick and show signs of life. Pigs have been revived up to a half hour after treatment began.

Examples of recent accomplishments of the State Agricultural Experiment Stations, prepared by the Cooperative State Research Service, are as follows:

Preventative for legume bloat. Bloat is a condition which develops when gases formed in the rumen are trapped in foam so that effective release by belching is prevented. It is estimated that bloat costs producers about \$100 million annually in death losses and losses in production. This condition occurs most commonly on pasturage rich in legumes and has been a major deterrent to the use of legumes. Legumes are generally more nutritious than grasses, especially having a higher protein content. Feeding legumes allows a considerable reduction in the expensive feeding of protein supplements. Kansas workers, with the help of Smith, Kline & French Laboratories, Philadelphia, have developed a compound, poloxalene, which is nontoxic, produces no detectable residue in milk or meat, acts rapidly to prevent foam formation, is effective for at least 12 hours and is economical enough for general use. It has received Food and Drug Administration clearance and is marketed as "Bloat Guard."

Toxic residue in animal tissue replaced. Utah Agricultural Experiment Station scientists discovered the ability of a low toxicity chemical such as DDT to replace a highly toxic chemical such as dieldrin in animal tissue. This has been demonstrated in the rat, and body fat of swine and sheep. The interaction of these insecticides in the animal body opens up the possibility of finding other even less toxic materials which stimulate the metabolism of chemical pollutants.

Radio-chlorine as a tracer in fat deposition. Radio-chlorine was used as a tracer in studying the deposition of fat in panniculus adiposus tissue at the Pennsylvania Station. Its short half-life makes its preparation from natural Cl by neutron activation simple and inexpensive, and minimizes long-term contamination. The tracer material was prepared by forming an additional compound of glyceryl mono-oleate and Cl which was put in gelatin veterinary capsules and exposed to thermal neutron radiation. The amount of induced activity was measured. The time required for digestion, absorption, transport and deposition of sufficient detectable radioactive material was 3.5 hours. Live animals were assayed and also tissue samples from slaughtered animals. Incorporation of radio-chlorine into the lipid molecule does not appear to alter the normal pathway of metabolism.

Standard for carcass merit in lamb. As a result of research in W-61, Development of Selection Criteria for the Genetic Improvement of Carcass Merit in Sheep, a definition of Carcass Merit in Lamb was developed



which is in effect, A Carcass Standard for High Merit. The Standard includes fat thickness over the loin, loin eye area, percent retail cuts, etc.

Antibodies to urease improve urea utilization by ruminants. Scientists at the Oklahoma Station have shown that the injection of urease (an enzyme which breaks down urea to ammonia) into ruminants causes an antibody level to be built up which in turn inhibits the action of the enzyme in the rumen. This inhibition results in a slower release of ammonia from the urea. The ammonia then may be more completely utilized by the rumen bacteria for the building of proteins.

Feeding protein supplements to cattle on the range. During much of the year the forage available on the western ranges is too low in protein content to supply the needs of cattle for efficient production. Some form of protein supplement must be fed if satisfactory production is to be obtained. A major cost to such feeding is the labor required to distribute the supplement to the cattle. New Mexico workers have demonstrated that frequent feedings are unnecessary. When feedings are spaced at weekly intervals, results were equal to more frequent feedings. Their most recent report indicates that feedings spaced two and three weeks apart are, also, very effective in providing the protein needs of range livestock. Such information will allow ranchers to appreciably reduce labor costs.

Crossbreeding in dairy cattle. Investigations in crossbreeding dairy cattle have indicated that while crossbred animals have greater productivity than the average of their parental breeds that they do not reach the level of milk production of the Holstein breed. With a pricing situation that favors pounds of milk rather than butterfat test, both the crossbred animals and the animals of low milk producing breeds are frequently at a disadvantage when compared with Holsteins. The principle advantage of the crossbred animal deals with reproduction, including embryonic mortality and calf death losses at birth and during rearing. The result of this advantage is that there are more crossbred replacement heifers than purebred heifers to go into the milk string for each cow that was originally bred. Work with crossbreeding has been conducted at the Illinois, Alaska, South Carolina, Georgia, Louisiana, and Texas stations with generally the same pattern of results. Part of the difficulty encountered in crossbreeding is the inavailability of a second high milk yielding breed which might be crossed with the Holstein in expectation of heterosis.

Crossbreeding in beef cattle. A program of research on crossbreeding in beef cattle is in progress at several of the state stations and useful information is being attained. The use of some of the larger breeds of cattle, including Charolais, Charbray, Brown Swiss, and Holstein has produced faster gaining cattle than the conventional beef breeds when used in crosses with the beef breeds. Heterosis in both gaining ability and in reproductive capacity has been demonstrated in a wide range of crosses of cattle for beef production. Research has been conducted by

Virginia, Alabama, Louisiana, Texas, California, Iowa, Missouri, Ohio, Nebraska, and other states. With the volume of effort currently underway, it should be possible to soon establish the economic advantages and disadvantages of crossbreeding with various breeds of beef cattle. Levels of heterosis have been 3-4% for growth in crosses of Hereford, Angus, and Shorthorn crosses, up to 10% for growth when large breeds were included in the cross, and 5-10% increase in reproductive rate of cows carrying crossbred calves and of crossbred cows. These levels of heterosis are economically significant and use of crossbreeding in commercial beef production is increasing.

Genetic markers in livestock. During the last few years numerous simply inherited genetic polymorphisms in blood and milk proteins of farm animals have been identified. These genetic markers have proven very useful in population studies with livestock as well as potentially being associated with various productivity traits. For example, five different serum proteins in swine with known genetic variations are being followed at the Iowa station to determine effects of radiation on changes of those "traits." Similarly in chickens, immunoglobulins show genetic variability and are being studied for possible association with egg production as well as for linkage studies at the Iowa station. At the Ohio, Minnesota, and Louisiana stations, dairy cattle are being characterized for transferrins with intent to associate these variations with reproduction and production levels. At the Delaware station, research will soon be initiated to relate several of these genetic polymorphisms of blood and milk to productivity traits. New developments in cytology has permitted better identification of the chromosomes of domestic animals; a recent study at Tennessee has indicated that the wild boar has one more pair of chromosomes than the domestic hog with other chromosomes appearing similar. Work at the Texas station in basic beef cattle genetics is using the above tools as well as blood-typing to genetically characterize beef cattle. This research carries the science of animal breeding much closer to the level of gene action than has previously been possible.

Development of artificial insemination for swine industry. The benefits of artificial insemination have now been made available to the swine industry through research conducted under the NCR-26 regional project initiated in 1961. Illinois, Indiana, Michigan, Missouri, Minnesota, Ohio and Wisconsin were major contributors. Successful procedures for collecting, diluting and transporting boar semen and for inseminating sows without loss of fertility were developed from this research and adapted for commercial use. A boar stud has been established by Tri-State breeders cooperative at Platteville, Wisconsin. From this stud alone serving a 2 or 3 county area 3,000 sows were bred to production tested boards in 1965. By 1967 it is expected that 10,000 sows will be bred from this stud. A somewhat similar development is occurring in northern Illinois.

Temperature effects on embryos and sperm identified. North Carolina workers have shown that sheep embryos exposed to as little as 2 degrees



temperature increase over normal body temperature during early development (1st. or 2nd. cell division) do not survive. Similar exposure at later stages do not affect embryo survival. Preliminary results also indicate that similar exposure of spermatozoa appears to produce effects which decrease survival rate in embryos resulting from eggs fertilized by treated sperm. The effects of temperature stress on fertility of sheep thus have been identified as occurring during a relatively short period following fertilization. Protection from temperature stress during this critical period has been shown to result in increased reproductive rate of sheep. In work at Arizona it was also shown that protection of cattle from heat stress for 100 hours or more following breeding increased reproductive rates from 20 to 70 percent indicating a similar critical period in embryo development in this species as in sheep.

Ultrastructure of bovine sperm. Workers at Pennsylvania through the development of sophisticated techniques of electron microscopy have provided a more detailed description of the structural components of spermatozoa than has been hitherto provided by older techniques. Changes in structure hitherto unrevealed in relation to procedures used in freezing and other means of preserving semen and in relation to fertility of bulls have been noted. This work is being continued at Virginia and being extended to studies of milk secretion cells.

Test tube milk production. How is milk made? To answer this question, dairy scientists at the University of Illinois have developed for the first time anywhere, a method of growing mammary tissue outside the cow. Although it has been possible to keep these secretory cells from the udder functioning for brief periods only, these scientists hope eventually to answer the question, "How is milk made?", that is, what nutrients, hormones, enzymes, etc., are required, and in what amounts for the most efficient production of milk. We already know each secretory cell in the udder is a complete factory unto itself manufacturing milk per se from the precursors it obtains from the bloodstream. The question is how, and can we by improving the ratio of the available precursors, improve the production of our dairy cows, especially the less efficient producers.

Calcium-phosphorus imbalance can produce typical symptoms of atrophic rhinitis in swine. Atrophic rhinitis is a disease characterized by varying degrees of loss of nasal turbinates. Research at the New York (Cornell) Agricultural Experiment Station has shown that typical symptoms of atrophic rhinitis can be produced by feeding diets low in calcium or by a dietary calcium-phosphorus imbalance. The relationship between dietary calcium and phosphorus and atrophic rhinitis will be studied further to determine whether atrophic rhinitis is primarily a mineral deficiency disease or if a nutritional deficiency makes the animal susceptible to infectious agents.

Feeding oats diets to swine reduces the incidence of stomach ulcers.

Research at the Wisconsin Agricultural Experiment Station has shown that feeding rations containing a high level of oats were effective in preventing erosions and ulcers as well as epithelial changes associated with ulcers in swine. Rations containing 85% oats produced all normal stomachs while the stomachs of pigs fed diets containing 76% corn showed erosions and ulcers. The mechanism whereby ulcer development is prevented by the oat diet has yet to be established.

Lamb crops can be increased. Research at California, North Carolina, Texas and Virginia has shown that by breeding and selection and particularly by more intensive management, it is possible to increase lamb crops by about 50 percent. At Virginia, it was shown that by a system of early weaning and more intensive management of ewes and lambs it was possible to produce a lamb crop every 7 months. Productivity of the lamb crop was also improved. Similar results were obtained in North Carolina.

Breeding season control for cattle, sheep and swine through estrus synchronization. Physiological studies on the use of hormones and other chemicals to control the heat cycle in livestock which has been under intensive investigation for the past 5-6 years, has now culminated in the development of successful procedures for controlling heat periods and thus the breeding season of cattle, sheep and swine. California, Illinois, Iowa, Kansas, Michigan, Missouri, Nebraska and New York have participated extensively in this work. This development makes it possible to control the breeding season of these classes of animals to relatively short and desirable periods of time. It simplifies and reduces management cost and promises to make the application and benefits of artificial insemination more useful to the beef, sheep and swine industry than has been the case in the past.

Plasma free amino acid level reflects deficiency of dietary amino acids. Studies at the Illinois Agricultural Experiment Station indicated that the plasma free amino acid level can be used for determining the availability of the amino acids contained in dietary proteins. A technique has been developed for evaluating the availability of amino acids contained in poultry feedstuffs utilizing the chick as the assay animal. The relative availability of amino acids in a test protein is determined by a comparison of the plasma free amino acid patterns of chicks fed the test protein with those fed a standardized diet.

Persistence of insecticides in chickens and eggs. Scientists at the Indiana Agricultural Experiment Station fed low levels of insecticide for short periods of time to laying hens to simulate accidental contamination of feed. When 0.1 to 0.15 p.p.m. of lindane, dieldrin, heptachlor and DDT were fed daily in capsules for 14 days, no residues were detected in eggs. From 0.2 to 0.3 p.p.m. of lindane and DDT were found in the abdominal fat of the birds. However, 4 weeks after insecticide feeding was discontinued, no residues were detected. When 10 to 15 p.p.m. of the same insecticides were fed for 5 days, significant residues were found in both eggs and



abdominal fat and they were extremely persistent. Abdominal fat contained 1 p.p.m. of dieldrin and 0.7 p.p.m. of DDT as long as 26 weeks after exposure. It is important to insure that feeds do not contain high levels of chlorinated hydrocarbon residues.

New management system for egg layers. Researchers at the Pennsylvania Agricultural Experiment Station have developed a laying house management system which permits high productivity of layers and efficient use of labor. It offers a solution to the manure problem now plaguing the commercial poultry industry. The unique features of the new system are a sloping wire floor and a newly developed plastic rollaway nest. Floor eggs roll to the aisle where they are easily gathered, along with nest eggs from trays behind the rollaway nests. In addition to solving the floor-egg problem, the new system aids materially in manure handling. Droppings fall over the total floor area under the wire floors. The ventilation system combined with daily agitation greatly reduces the moisture content of droppings. The putrefactive odors associated with poultry manure are absent. The manure is so dry it can be easily spread on land, bagged for commercial use, or incinerated. Flies are controlled by a chemical spreader attached to the agitator.

New housing and management system for raising broilers. West Virginia Agricultural Experiment Station researchers have developed a radically new broiler house. The new house has a small, a medium and a large room. Baby chicks are started in the small room. At 3 weeks of age they are moved into the middle room and 3 weeks later to the large room. As the small room is vacated, it is cleaned and a new brood is started. Chicks of 3 different ages are reared in the same house at the same time. In the new house, cost of brooding is considerably less and more efficient use is made of space. However, more careful management is needed and the cost of housing per square foot is increased. Live weights, feed efficiency and mortality after 2 years research compare favorably with conventional systems.

Wet litter causes breast blisters. Georgia Agricultural Experiment Station researchers reported that wet litter resulted in much greater incidence of breast blisters in broilers than dry litter. At 9 weeks of age the controls had 1.12% breast blisters, the wet litter group 6.67%. At 12 weeks of age the percentages were 6.05 and 12.25%, respectively. It has been estimated that economic loss due to carcass defects is about twice that due to condemnations. Thus, it is important to keep the litter dry.

Lysine restriction delays sexual maturity of meat type pullets. Researchers at the Connecticut Agricultural Experiment Station have developed a method of delaying sexual maturity by restricting the amino acid lysine in the diet of the chick from day of age to 12 weeks of age. Delaying sexual maturity increases initial egg size. Pullets from chicks started on lysine deficient diets laid fewer eggs prior to 26 weeks of age but laid more eggs from 26 to 66 weeks of age than did those fed a normal ration.

Carbon dioxide or sodium bicarbonate increases egg shell thickness.

Studies at the California Agricultural Experiment Station have shown that egg shell thickness can be increased by increasing the carbon dioxide content of the atmosphere in the chamber housing laying hens or by adding sodium bicarbonate to the drinking water. Increasing the carbon dioxide content of the atmosphere resulted in a 12% increase in egg shell thickness. The addition of sodium bicarbonate to the drinking water and simultaneously reducing the salt content of the diet increased egg shell thickness approximately 7%.





## AREA NO. 1: ANIMAL BIOLOGY

Problem. The extent of applicable results in animal husbandry research is severely limited by a paucity of basic information on the genetics, nutrition, and physiology of our livestock. The basic research in progress has resulted primarily in revealing the inadequacy of our information regarding the functional processes within the animals we are trying to control and develop for human use. Basic research is required in such fields as animal cell metabolism and reproduction, enzymology, physiological bases for heredity, and microbiology of the rumen and intestines. Results of such studies provide the basis for additional research applied to the husbandry of each type of livestock.

### USDA AND COOPERATIVE PROGRAM

This area consists of basic research conducted by anatomists, geneticists, biochemists, physiologists, and nutritionists. It includes studies in the Pioneering Laboratories on somatic variations of red cell antigens, on the nature of the specificity of antigens and antibodies, on methods and theories of population genetics, and on the physiological aspects of hormones. Research in reproductive physiology is in progress to determine the biochemical composition and the defensive mechanisms of the uterus. Still other physiological investigations are involved with the response of mammary tissue to invasion by infectious agents. One study of long standing has the primary objective of describing, fully and in detail, the gross and microscopic anatomy of the domesticated fowl. Research on the metabolic role of vitamin B<sub>12</sub>, the investigation of unidentified nutrients in food and feed, and biological and chemical studies of rumen metabolism are also being undertaken. Investigations are in progress on the development of counter measures to prevent contamination of animal products by fallout from nuclear explosions. The work is conducted at Beltsville, Maryland; East Lansing, Michigan; Fargo, North Dakota; and in cooperation with the Indiana, Iowa, Maryland, Michigan, Minnesota, New York, Utah, and Wisconsin Agricultural Experiment Stations.

The Federal scientific effort devoted to research in this area totals 18.7 professional man-years. Of this total, 6.0 are in agricultural chemicals, 2.0 in avian anatomy, 3.0 in genetics, 4.3 in physiology, 2.4 in nutrition, and 1.0 in rumen function.

There are 9 grants involving Public Law 480 funds in foreign countries financing research related to animal biology. Three of these are in Israel. Two are with the National and University Institute of Agriculture at Rehovot, and provide for (1) studies on the separation of young and old spermatozoa and (2) investigation of factors affecting long-term storage of sperm. They are supported for 3 years (1963-1966) with a total of \$86,904 equivalent in Israeli pounds.

One project at Hebrew University at Jerusalem, is a study of water transport through animal membranes, including the influence of the pH and the ionic composition of the bathing fluids on the effect of vasopressin. It is supported for 3 years with a total of \$49,767 equivalent in Israeli pounds.

There are 3 PL 480 projects in Poland. One is on the secretion of anterior pituitary hormones and ovulation in small ruminants. It is supported for 5 years (1960-1965) by \$52,455 equivalent in Polish zlotys at the Polish Academy of Sciences, Jablonna. A 4-year project (1962-1966) at the College of Agriculture, Poznan, is concerned with protein compounds of vitamin B<sub>12</sub> and its analogs. It is supported with \$38,138 equivalent in Polish zlotys. Another project is at the Polish Academy of Sciences, Warsaw. It involves the determination of the metabolic pathway of protein biosynthesis in the liver and has a 5-year duration with support amounting to \$60,411 equivalent in Polish zlotys.

A project on metabolism of zinc in living organisms by means of zinc 65 is in progress at the Institut Espanol de Fisiologia y Bioguimica, Madrid, Spain. It has a duration of 4 years (1961-1965) and is supported by \$35,277 equivalent in Spanish pesetas.

The University of Montevideo, Uruguay, is conducting a project of 5 years' duration on the nutritional value of fish silage. It has \$112,785 equivalent in Uruguayan pesos of support.

A project with the Hebrew University, Jerusalem, Israel, is on the effect of X-rays on viability genes with special reference to their action in heterozygotes and to the mechanism of heterosis. The project duration is 4 years and has support of \$34,650 equivalent in Israeli pounds.

#### PROGRAM OF STATE EXPERIMENT STATIONS

The total research effort on animal biology by State agricultural experiment stations is 197.4 scientific man-years.

#### PROGRESS -- USDA AND COOPERATIVE PROGRAMS

##### A. Agricultural Chemicals

This research on basic metabolism, fate, and role of agricultural chemicals ingested by livestock is conducted at the Metabolism and Radiation Research Laboratory, Fargo, North Dakota.

1. Herbicides. Investigation of the metabolic fate in the animal of the triazine herbicides has been continued. Studies have been conducted with Propazine, Atrazine, Simazine, and Prometone in the rat, milk goat, and/or sheep.



Rat: Prometone is completely eliminated in the urine and feces within 3 days after an orally administered dose. Within 4 days 91% of the radioactivity of an orally administered dose of Propazine is excreted in the urine and feces. Tissue residues are found up to 12 days after dosing. These residues are fairly uniformly distributed in the organs and tissues examined, except for consistently lower levels in the brain and higher levels in the skin.

Type of diet appears to affect the urinary excretion of Propazine. It is postulated that availability of carbohydrate influences the urinary excretion of Propazine metabolites.

Goats: When radiolabeled Propazine was administered orally, approximately 41.5% was excreted in the feces and 43% in the urine in 72 hours. Less than 2% of the urinary activity is soluble in chloroform, indicating the formation of water-soluble Propazine metabolites. More than 97% of the fecal activity, on the basis of chloroform solubility, is Propazine or hydroxypropazine. Milk secretion of radiopropazine equivalents reached a maximum of 1.5 ppm in 16 hours, and declined to 0.17 ppm 72 hours after dosing. Radiopropazine equivalents in the tissues averaged 0.88 ppm, with the highest residue of 1.5 ppm found in the kidney. Urinary recovery of radiolabeled, orally administered, Atrazine and Simazine was 66.5% and 74.0, respectively.

Sheep: With ring-labeled Atrazine, 67% and 26% of the radioactivity was excreted in the urine and feces, respectively. Dosed with radiosimazine, a sheep excreted 77% of the radioactivity in the urine and 13% in the feces.

General: Radiolabeled CO<sub>2</sub> is not found in the expired CO<sub>2</sub> of rats, milk goats, or sheep administered ring-labeled triazines. This indicates that the animal body does not cleave the triazine ring. On the other hand, ethylamino group of Atrazine and Simazine is rapidly metabolized to CO<sub>2</sub> by these animals. Propazine is metabolized by the rat to at least 18 compounds and Prometone to at least 11. In the goat, 16 urinary metabolites of Propazine have been separated. The number of metabolites, in the absence of ring cleavage, suggests that the metabolic pathway of triazine involves various conjugation reactions. (AH k1)

2. Insecticides. A study of the metabolic accumulation and excretion of the chlorinated hydrocarbon, dieldrin, in sheep has been initiated. Variables investigated include 4 levels of dieldrin, 2 levels of energy intake with 2 sources of supplemental energy, and 5 slaughter intervals. Sheep fed 4 mg/kg body weight of dieldrin daily died in convulsions within 4 weeks; a few sheep fed dieldrin at a rate of 2 mg/kg body weight daily have been observed in convulsions, with spontaneous recovery. (AH k1-1)

3. Feed adjuvants. The isolation, identification, and quantitation of the excretion products of diiodosalicylic acid (DIS) by the rat and cow has been continued. Current activities have emphasized the use of

DIS labeled with C<sup>14</sup> in the carboxyl position. The urine was the major route of excretion, and pretreatment with DIS influenced the percent of the dose excreted in the urine. This could be caused by a dilution of the C<sup>14</sup>DIS by unlabeled DIS in the diet and (or) an overloading of the kidney. Rats receiving high levels of unlabeled DIS at time of dosing had considerably more C<sup>14</sup> in the skin and hair than those receiving low levels. This would make external contamination an unlikely explanation of the C<sup>14</sup> observed in the skin and hair. It is probable that secretion through the skin was occurring. The concentration of C<sup>14</sup> in tissues of the gastrointestinal tract and kidney tended to be the highest. The brain, leg muscle, and omental fat had markedly lower concentrations.

A 16-month-old Guernsey freemartin was dosed with C<sup>14</sup>DIS. This animal had received 1 mg DIS per body weight for 17 days prior to dosing. The percent of the dose of C<sup>14</sup> excreted via the urine and feces for the 10-day period was 99.1 and 2.9, respectively. Peak levels of C<sup>14</sup> in blood plasma occurred between 18 and 48 hour post dosing.

Freezedried urine from rats dosed with C<sup>14</sup>DIS was extracted and chromatographed. The C<sup>14</sup> was eluted in two fractions. Fraction 1 showed two major peaks, one of which corresponded to the retention time of derivatized DIS. The tentative hypothesis is that the rat forms at least two urinary metabolites. One of these appears to be DIS or a very similar compound(s). The other is probably a glycine conjugate of salicylic acid. There are indications that one, or both, of the iodine atoms have been removed from this molecule. (AH kl)

4. Microbiological studies. Techniques and procedures have been developed to maintain calves under isolation conditions from birth, that have been successfully kept free of rumen ciliated protozoa or of harboring the ciliate Entodinium simplex or Isotricha sp.

Following this isolation, Entodinium simplex was successfully inoculated and maintained in a male Guernsey. A mixture of Isotricha prostoma and Isotricha intestinalis was successfully inoculated and maintained in a female Guernsey and compound to another male Guernsey was successfully maintained free of ruminal ciliated protozoa. The volatile fatty acid concentrations in ruminal digesta of these animals indicate that bovines, supporting either a large population of holotrichs or oligotrichs, or devoid of ruminal ciliated protozoa, show relatively the same proportions of acetic, propionic, and butyric acids. The total volatile fatty acid concentrations of acetic, propionic, and butyric acids have also been shown to be very similar in a bovine harboring only holotrichs, and in a bovine harboring only oligotrichs.

Although studies have demonstrated that the ruminant animal absorbs and metabolizes Propazine rapidly, rumen microorganisms have not shown an ability to metabolize this pesticide in vitro. An in vivo experiment



has now illustrated that rumen organisms do not adapt to the metabolism of Propazine. Also, sheep can readily remove Propazine from the gastrointestinal digesta without rumen-reticulum microbial metabolism.

Pesticidal compounds representing carbamate, chlorinated hydrocarbon, organophosphate, fluorinated, and other pesticidal compounds have been respirometrically evaluated with washed ruminal mixed bacterial cell suspensions (37 compounds), Entodinium simplex suspensions (15 compounds), and Isotricha sp. (32 compounds).

Endogenous gaseous release indicating metabolism of the compounds is stimulated in rumen bacterial suspensions with the organophosphates, dicapthon, and Dysterex phosphonate. Endogenous gaseous release is stimulated in Entodinium simplex suspensions with Bidrin, Di-syston, parathion, and phosphamidon.

Endogenous gaseous release is stimulated in Isotricha sp. suspensions with Casaron, Bidrin, dicapthon dysterex, Di-syston, parathion, phosphamicon, ronnel, and Tabutrex.

Isotricha sp. suspensions, incubated with these pesticidal compounds:

Diazinon, labeled in the diethyl group and incubated with Isotricha sp. suspensions, was 92% metabolized; if labeled in the ring, was 12% metabolized. Guthion, labeled in the triazine ring, was 25% metabolized. Chloro-IPC showed no evidence of degradation. Trifluralin, labeled in the propyl group, was 63% metabolized. Bidrin, labeled in the methoxy group, was 47% metabolized. (AH kl-1)

## B. Avian Anatomy

Significant progress has been made during the past year toward completion of the volume in avian anatomy on the integumentary system. Typescript and illustrations for 6 of the 10 chapters are now in the hands of ARS editors. These chapters, consisting of a total of 1195 pages and 227 original illustrations, are as follows: (1) Topographic Anatomy, (2) Principles of Pterylosis, (3) Pterylosis and Ptilosis, (4) Molts and Plumages of Chickens, (5) Structure of Feathers, and (6) Structure of Feathers of Domestic Birds. The remaining chapters are near completion and have the following titles: (7) Histology of Feather Follicles, Growth of Feathers, and Coloration, (8) Feather and Apterial Muscles, (9) Microscopic Structure of the Skin and Its Derivatives, and (10) Technics Used in the Study of Avian Integument. Five species have been under investigation; chicken, turkey, domestic duck, coturnix quail, and common pigeon.

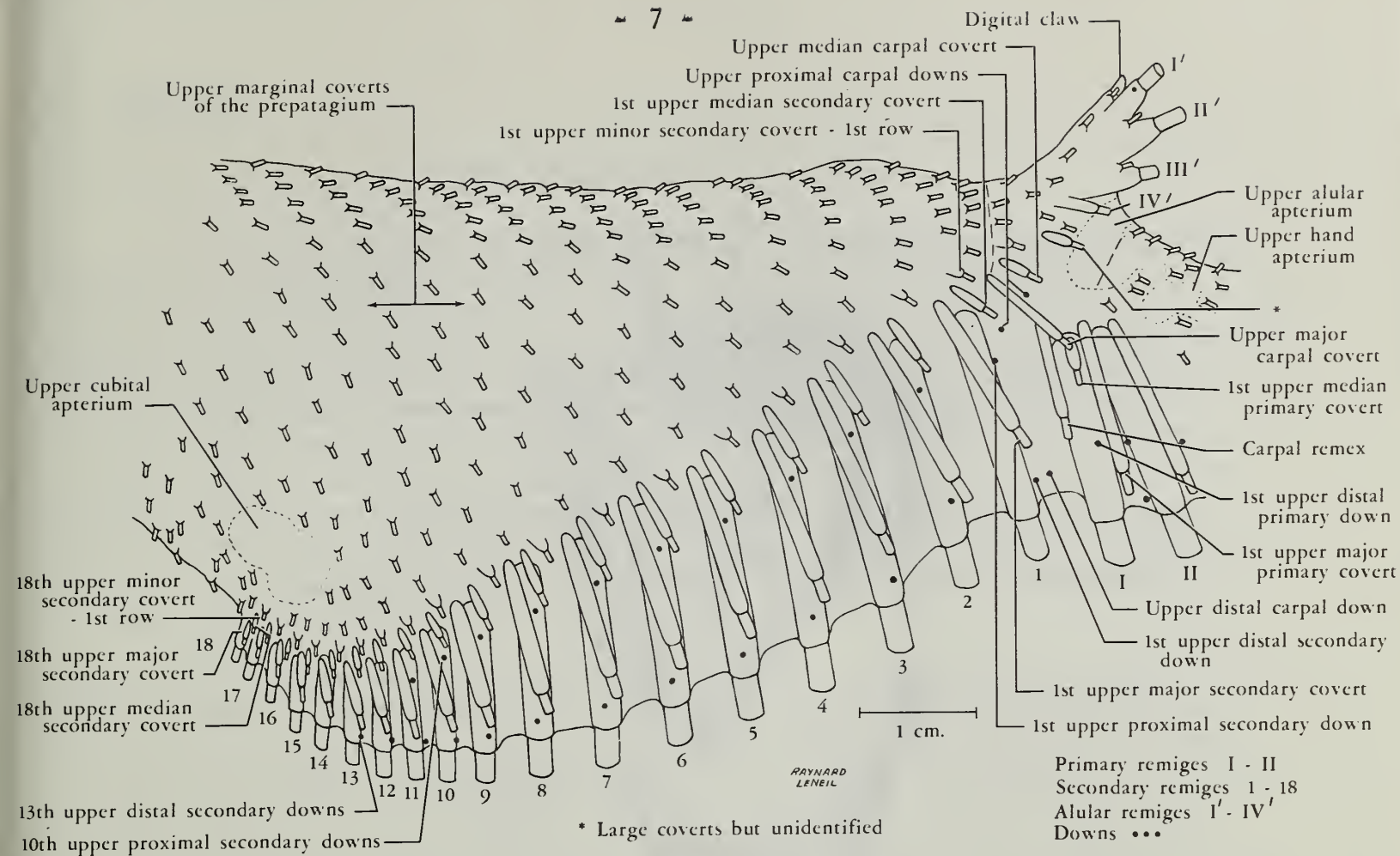
Their prime function of this material is to supply information in full detail for all who are concerned with domesticated birds so that those who have a specific question may find a definite answer. Examples of the

amount of detail needed are given in the following illustrations. The feathers on the dorsal surface of forearm and hand of the chicken are labeled. In a third drawing, the various parts and layers of the basal end of a feather shaft are labeled.

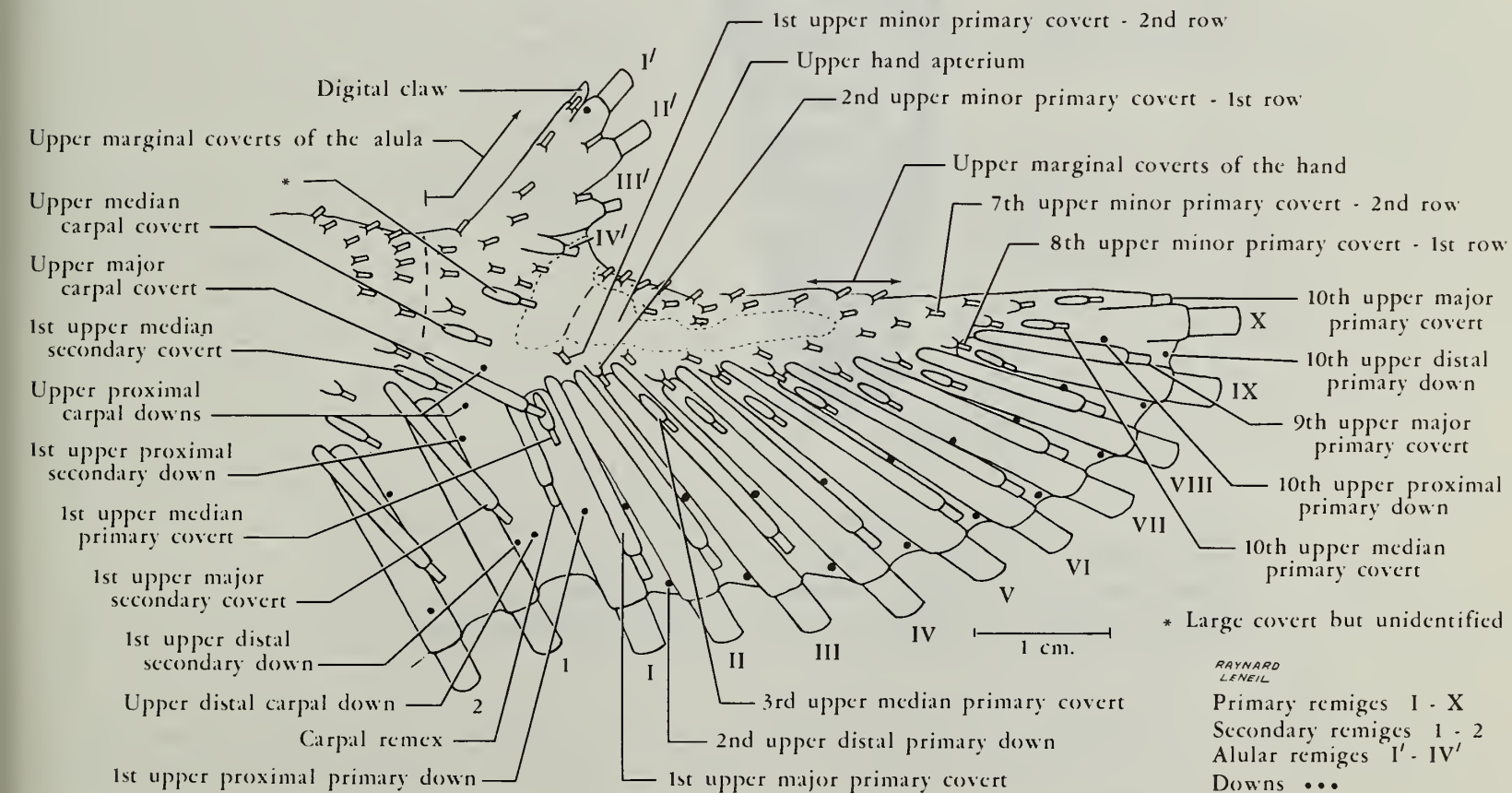
The geneticists and the pathologists are interested in persistent anomalies of certain feathers and groups of feathers. The poultryman has long been interested in the rate of growth and sequence of the primary and secondary remiges but the pattern and identification of the other feathers were not previously available. With this data now at hand, these and other disciplines can move forward effectively toward gathering data of practical value.

Many illustrations have been included in this volume to show tissues and developmental stages of a growing feather. This type of record is of particular value to the poultryman, the processor, the pathologist and the experimental embryologist.

It is hoped that the terminology used here will aid in stabilizing the present confused field. (AH e8-1)

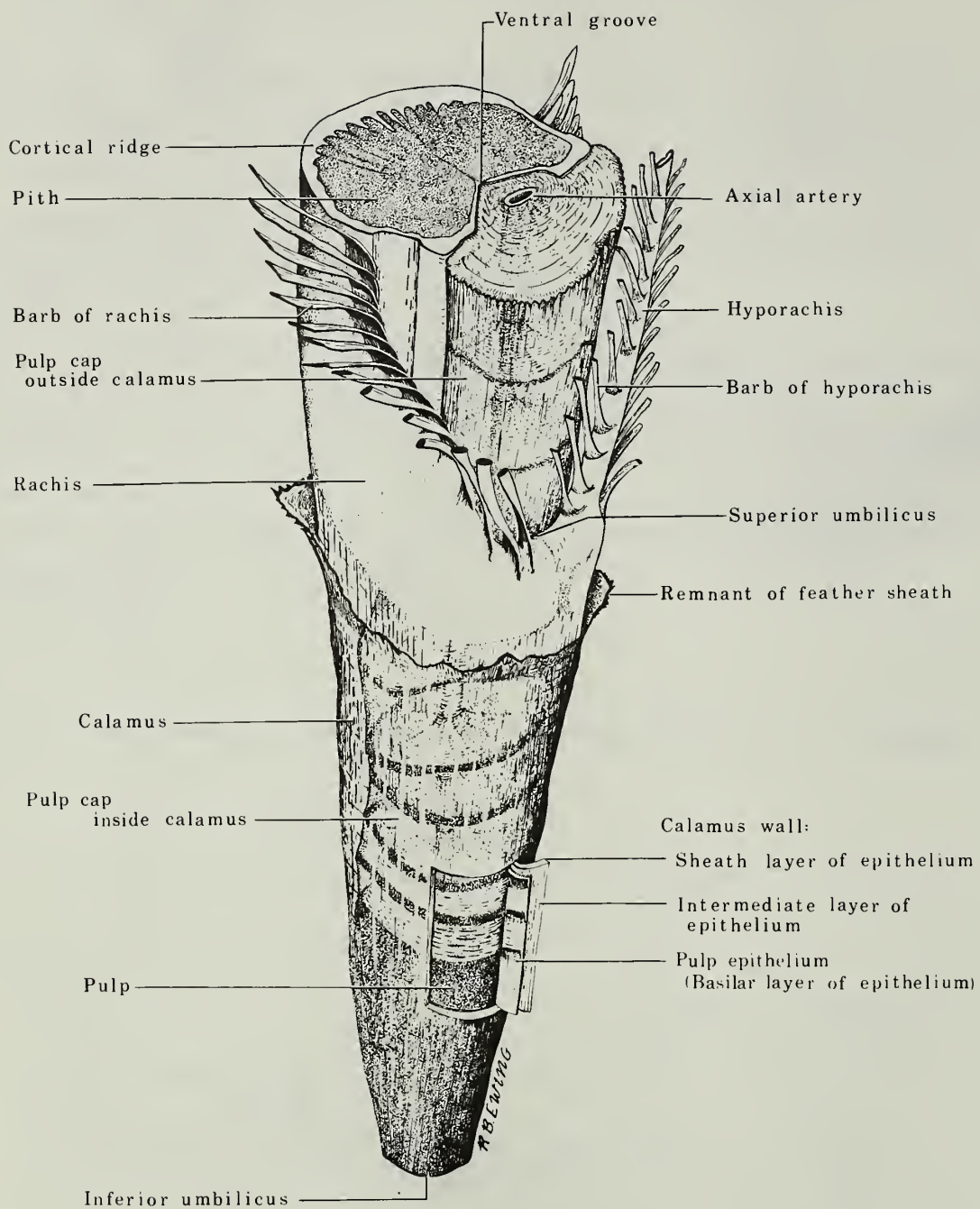


### Feathers on the forearm of the chicken - upper surface



### Feathers on the hand of the chicken - upper surface





Base of a growing feather showing the continuity of pulp caps inside and outside the calamus and their relationships to the superior umbilicus and to rachis and hyporachis of main feather and afterfeather.

## C. Genetics

### 1. Methods and theories of population genetics.

#### (a) Genetic parameters of protein metabolism and growth in mice.

The genetic relationship between body size and protein metabolic activity and the significance of protein metabolic activity in the genetic manifestation of growth were studied in cooperation with Purdue University. Protein metabolic activity was measured as the rate of transport of a C<sup>14</sup>-labeled model amino acid, alpha-aminoisobutyric acid (AIB), into tissues. Data were obtained at 28 and 42 days of age on body weight, carcass weight, carcass nitrogen content, and the rates of transport of AIB into muscle and liver tissues. The measurements at each age were taken on full-sib male progeny from an unselected random-mated population of mice. Totals of 393 and 392 progeny were measured at 28 and 42 days of age, respectively.

Many of the standard errors of genetic parameters were large because of the limited number of progeny which could be processed. However, the point estimates yield valuable information on the nature of the relationships between the traits, and on the feasibility of further research on the quantitative genetics of biochemical traits related to growth. Heritability estimates based on sire components of variance for 28 and 42 day body weight and carcass weight were high as was the estimate for 28-day carcass nitrogen. Nitrogen content of the carcass at 42 days of age gave a low heritability, suggesting that the carcass content of nitrogen at this older age is primarily a function of the environment. Heritability estimates for the measure of metabolic activity used were zero for liver tissue and low for muscle tissue at both ages.

Estimates of genetic and phenotypic correlations demonstrated that low phenotypic relationships existed between metabolic activity and the estimates of body size, but that strong positive genetic associations existed between metabolic activity at 28 days of age and body weight, carcass weight, and carcass nitrogen at 28 days. A smaller and negative genetic relationship was found between metabolic activity at 42 days and body weight and carcass nitrogen at 42 days, while that with 42-day carcass weight was small and positive. The genetic correlation between metabolic activity at 42 days of age and gain in body weight from 28 to 42 days was 0.61 while the genetic correlations between body weight at 28 and 42 days and weight gain were substantially smaller.

This evidence suggests that genetically large individuals at 28 days of age were also the most active metabolically, but that the reverse was true at 42 days. Such a conclusion implies that smaller individuals at an early age tend to gain faster, and/or longer, than larger individuals. It is postulated that the important genetic relationship with regard to growth patterns exists between gain and protein metabolic activity at a given



time, rather than between gain and body weight. The evidence obtained also indicates that protein metabolic activity plays a significant role in the processes leading to the phenotypic expression of body size. (AH p-2)

(b) Reproduction and estrus cycles of females, and libido of males, in a plateaued population of mice. Investigations of the nature and causes of selection plateaus and methods for overcoming them were continued through the fifth cycle of selection, in cooperation with Purdue's Population Genetics Institute. Reproductive problems in the plateaued strains in the form of a high rate of apparent sterility prompted a preliminary study of reproduction in the Goodale Large White Strain.

A total of 98 males was each mated to 4 females for 2 weeks. Each of the 392 females was checked twice per day for the presence of a vaginal plug as evidence that mating had occurred. These within-strain matings provided information on the libido and apparent sterility of the males. Twenty-eight (28.6%) of the males were sterile (no progeny from any of 4 mates) and no vaginal plugs were observed in any mate of 12 of these males. Although the average age of males was approximately 80 days, late sexual maturity of males cannot be ruled out as a possible cause of difficulty.

Of the 392 females, 18.4% showed vaginal plug(s) and littered, 18.0% showed no vaginal plug and littered, 16.1% showed vaginal plug(s) and didn't litter, and 47.5% showed no vaginal plug and didn't litter. The percentage (36.4) of females littering was low but was typical of the percentages obtained in several of the generations. No vaginal plugs were observed in almost half of the females which littered. It is obvious that the checks for vaginal plugs failed to identify mating in many cases, and may require changes in timing. Nearly half of the females which showed evidence of mating did not litter. Failure in these cases could have occurred at fertilization, at implantation, or at any embryo stage. Pre-weaning mortality of whole litters was 21.1% and only a few of these litters were dead at birth. The average calculated length of gestation (19.2 days) for females which showed vaginal plug(s) was rather short.

Beginning 4 weeks after mating ended, vaginal smears were collected on 18 consecutive days from 125 of the females which showed no vaginal plug and didn't litter. In general, the estrus cycles of these mice were unusual. Only 5 females had cycles which could be classified as regular. Most females had cycles which were quite variable, and many had long periods of proestrus.

Sixty-four percent of the females had one or more cycles complete from estrus to estrus, with an average cycle length of 5.9 days (long for mice). Seven percent of females showed no estrus, and 15% showed long periods of continuous estrus. The latter is an unexpected category of abnormal and indicates a high level of estrogenic hormone. Fourteen percent of the females showed only one time in estrus, and at least some of these may have

gone into pseudopregnancy as a result of the vaginal smearing technique. It appears that various types of abnormal estrus cycles may be important causes of reproductive failure in this plateaued strain. (AH p-2)

## 2. Basic research on blood antigens and antibodies.

(a) Somatic variation of red cell antigens. Experiments on selection against the "A" inagglutinable cells in circulating blood, described in previous years provided evidence that total body X-irradiation of pigeons increases the frequency of "A"-negative (inagglutinable) cells. This increase persists for the 4-month test period. Two pigeons retested a year following irradiation have also shown a greater frequency of "A"-negative cells than that present prior to irradiation.

In these experiments three findings, suggestive of in vivo selection against the "A"-negative cells, were obtained. (1) A dose of 360 r of X-rays usually resulted in an increase in the "A"-negative cell frequency, whereas a dose of 900 r or greater resulted in a decrease; (2) Several birds did not respond with an increase in the "A"-negative cell frequency at 2 and 4 months following irradiation with 360 r; and (3) Three of these non-responders were given an additional 360 r which resulted in a further decrease in the "A"-negative cell frequency; eight months later their frequencies rose until they approached the pre-irradiation levels. It was postulated that all of these negative responses to irradiation were the result of selection against the "A"-negative cells.

Indirect methods of testing selection were used, in which the cell lifetimes of "A"-negative cells were compared with that of the total cell population. The procedures involved labeling the cells with  $\text{Cr}^{51}$ , reinjecting them into the donor, and sampling the blood. In a preliminary experiment 3 birds averaged a 3.57-fold reduction at 7 days post transfusion, in comparison to the total cell population which showed no decrease in survival.

In another series of experiments in which birds were irradiated with 360 r, a comparison was made between birds which had shown no effect following irradiation and birds which had shown an increase in the "A"-negative cell frequency following irradiation. The "low-response" group averaged a  $3.75 \pm 0.56$  reduction in cell lifetime, as compared with  $0.80 \pm 0.88$  for the "high-response" group. The latter was not significantly different from the total cell population whose cell lifetimes were normal. The cell lifetimes of two control birds were also normal. This provides evidence for negative selection operating in the "low-response" group, and indicates a major basis for the observed variation in radiation response. (AH p-1)

(b) Embryological studies on the development of the A antigen in pigeons. These studies have been initiated in conjunction with the studies on somatic variation. The procedures used were direct agglutination with titration and mixed agglutination, using human cells as detectors in the



formation of rosettes. The antigen is first detected on the red cells between the eighth and tenth days. Increase in the number of positive cells is more rapid after the fourteenth day and reaches a maximum following hatching. (AH p-1)

(c) The nature of antigenic specificity. In the study of the "Hi" substance of chickens, a major unsolved question is how the cells are transformed to possess the "Hi" substance. One of the ways in which this transformation might occur is that terminal red cells become coated with the "Hi" substance from plasma. In order to test this thesis, a series of methods have been developed to label red cells in young and mature chickens with tritium. The presence of these labeled cells has been detected both by liquid scintillation counting methods and radioautography. It has also been possible to transfuse such labeled cells to sibs, and to detect them in the recipients by both radioautography and liquid scintillation methods. (AH p-1)

(d) Antibody specificity. The use of  $^{131}\text{I}$  as a label for proteins and antibodies has been found valuable in the study of antibody specificity. One of the steps in the labeling process requires the continuous dialysis of the labeled protein. If done manually, this is a time-consuming operation and has the additional disadvantage of exposure to the gamma radiation of the isotope. An automatic procedure has been developed which uses solenoids, relays, and timing devices. This allows for timed entry of buffered saline into the flask with the dialysis bag, and removal of the saline into a drain. The flask is kept behind a shielded sink. (AH p-1)

#### D. Physiology

##### 1. Physiological and biochemical characterization of uterine tissue.

(a) Changes in uterine glucose during estrogen-induced glycogen synthesis. One mechanism by which estrogen might control glycogen synthesis in the uterus would be to regulate the uterine supply of necessary substrates. If substrate availability were a rate-limiting process, an estrogen-induced change in cell permeability and alteration of the rate of transport into the cell might result in a stimulation of glycogenesis. Accordingly, changes in free uterine glucose were determined during the early, active phase of estrogen-induced glycogen synthesis.

Estrogen treatment produced a rapid increase in the free glucose concentration of the rat uterus. Comparisons were made of glucose space with chloride space (used as an index of extracellular volume) to determine whether glucose was being transported into the uterine cell in increased amounts during glycogen synthesis. The relative expansion for chloride and glucose should be similar if the glucose increase occurred entirely or primarily in the extracellular fluid compartment. The expansion occurring

in the glucose space was about 5 times greater than that of chloride, thus indicating that free glucose accumulated in intra-cellular water under the influence of estrogen stimulation.

Alloxan diabetes was utilized to provide rats of relatively stable metabolic condition with high circulating levels of glucose in order to determine the effects of estrogen and high blood glucose upon uterine glycogen and upon uterine glucose shifts. In alloxan diabetic control rats, the high blood glucose levels (600-700 mg%), about 5 times of normal rats, caused much higher uterine glucose levels and higher uterine glycogen concentrations than observed in normal rat uteri. Estrogen treatment for 6 hours produced a further increase in uterine glucose and uterine glycogen.

The glucose space again was about 5 times that occurring in the chloride space, indicating that even in the presence of extremely high levels of blood and uterine glucose, estrogen action results in an increased transport of glucose into the uterine cell and an increase in glycogenesis. The evidence derived from these experiments indicates that estrogen causes an increased availability of endogenous substrate glucose to the uterine cell. (AH h5-8)

(b) Comparison of uterine glycogen synthesis in the rat, rabbit and sheep. A comparative study was made of the glycogenic response of the uterus of the rat, rabbit, and sheep in the first 6 to 10 hours of estrogen stimulation. Essentially, similar 2- to 3-fold increases in glycogen concentration were observed. Rats and rabbits were also treated with alloxan to induce diabetes. The consequent high circulating glucose forced glycogen synthesis to proceed in the castrate uterus to a level almost as high as that achieved under estrogen treatment. Estrogen administration caused a further increase in glycogen concentration. In the sheep uterus, the endometrium and myometrium could be analyzed separately, and each tissue responded to estrogen with an increase in glycogen concentration.

Free uterine glucose was measured in each species to see whether an increase in glucose availability occurred and was involved in the mechanism of uterine glycogen synthesis. The relative expansion in glucose space was compared to chloride space (used as an index of extracellular volume) to determine if an influx of glucose into the uterine cell occurred. In the rat uterus and in the sheep endometrium, increases in free uterine glucose were observed, but the rabbit uterus and sheep myometrium synthesized glycogen without showing an increase in free glucose in the tissue. (AH h5-8)

(c) Inhibition of estrogen-induced glycogen synthesis by an antibiotic. Increased protein synthesis has been implicated as an early consequence of estrogen action and has led to the proposal that the primary



step in estrogen action involves a stimulation of some protein synthetic process. Experiments with puromycin, actinomycin D, and cycloheximide demonstrated that when protein synthesis was interrupted, certain of the characteristic tissue responses of estrogen action were abolished. Estrogen stimulates uterine carbohydrate systems, resulting in a marked increase in uterine glycogen. The present investigation was initiated to determine whether the estrogen-dependent increase in uterine glycogen synthesis would be altered when protein synthesis was inhibited.

Cycloheximide (actidione) or estradiol alone caused an increase in uterine water, weight, and free glucose. Sixteen hours after estrogen the uterine glycogen had increased 5-fold. When a single dose of actidione was administered 1/2 hour before estradiol, glycogen synthesis was suppressed for the first 8 hours, after which estrogen stimulated glycogen synthesis. Three doses of actidione, at 1/2 hour before, 5-1/2 hours after, and 10-1/2 hours after estradiol, were necessary to completely suppress the glycogen synthesis for 16 hours.

The influence of cycloheximide on glycogen synthesis after it had been initiated was studied by administering actidione after estrogen. Complete suppression occurred when actidione was administered 1-1/2 hours after estrogen, only partial suppression after 2-1/2 hours, and actidione was ineffective when administered 4 hours after estradiol. Consequently, there was an initial period of about 3 hours after estrogen treatment during which the glycogen synthetic system could be inhibited by cycloheximide. After this time, the presence of cycloheximide was unable to suppress glycogen synthesis. (AH h5-8)

(d) Effects of elevated blood glucose levels upon uterine glycogen.

Uterine metabolism and growth is an estrogen controlled process. Estrogen administration to an animal deprived of its natural hormonal influences (by removal of the ovaries) results in an increase in both uterine glucose and uterine glycogen. Since it seemed possible that the increase in uterine glucose might be directly involved in the mechanism of this glycogen synthesis, experiments were conducted to raise blood glucose by artificial means and to study consequent effects upon uterine glucose and glycogen concentrations. Ovariectomized rats, control or estrogen-treated, were made hyperglycemic by injecting glucose intraperitoneally (IP), subcutaneously (SC) or by stomach tube (ST), thereby raising blood glucose levels from 143 mg% to 700 mg%.

Uterine tissue responded to the high (5 x normal) levels of blood glucose with a corresponding 5-fold increase in uterine glucose at 2 hours. Similar levels were attained with all 3 routes of administration. The uterus showed some differences in the glycogen response, however, which appeared dependent upon the mode of administration of the glucose. ST and IP injections of glucose caused glycogen synthesis to proceed so that the high glucose castrate uteri had a glycogen content about 2 x normal uteri, 6 hours after



the start of the glucose treatment. The glycogen of uteri from subcutaneously injected glucose rats was not elevated over normal control levels.

Similarly, estrogen treatment revealed differences. Those uteri whose glycogen had been elevated by glucose (IP and ST) did not respond to estrogen with a further increase in synthesis, suggesting that the glycogen enzymatic machinery had already been stimulated maximally in the 6-hour period. On the other hand, estradiol produced its usual increase in uterine glycogen in the SC group. These experiments provide strong evidence that an increase in substrate glucose availability stimulates the rate of the glycogen system in the uterus. (AH h5-8)

(e) Studies on induced leukocytic responses in sheep uteri.

Uterine horns of ovariectomized, estrous and luteal-phase ewes were (1) flushed with physiological saline solution immediately prior to experimental inoculation with Escherichia coli; (2) manipulated to simulate flushing, then inoculated; or (3) inoculated only. The flushing treatment had a greater effect on the leukocytic response in cycling ewes than in ovariectomized ewes. The increase was not due to the manipulation associated with the flushing. The manipulation alone had some effect in the luteal-phase ewes. The results indicate that endocrine control of the acute inflammatory response in the sheep uterus can be modified by flushing the uterus prior to experimental inoculation. (AH h5-8)

(f) Investigations on the stimulatory effect of alfalfa hay on the uterus of ovariectomized ewes. In an earlier study endometrial vascular function was found to be greater in ovariectomized ewes fed alfalfa hay than in those fed orchard grass hay. Induced mold growth on the hays did not affect the vascular system. Workers have reported that the estrogenicity of alfalfa is associated with the degree of leaf-spot disease. In studying this, fields of alfalfa were selected for heavy infestation with leaf-spot disease and for relative freedom from disease. Pellets made from the two lots of alfalfa were fed to ovariectomized ewes. Pellets made from the diseased and disease-free alfalfa contained 222.4 and 16.7 ppm of coumestrol, respectively. Endometrial vascular function, water content, and epithelial cell height were each greater in ovariectomized ewes fed pellets made from diseased alfalfa than in ewes fed pellets made from disease-free alfalfa or orchard grass. Results showed a definite relationship between the disease state of alfalfa and the degree of its stimulation of the sheep uterus. (AH h5-8)

(g) Effects of intrauterine bacterial inoculation and suckling on the bovine corpus luteum and uterus. At Wisconsin, persistence of corpora lutea induced in post-partum cows by gonadotropin injection was produced with intrauterine bacterial inoculation. The initial response to repeated E. coli inoculations was a marked inflammatory response in the uterus. Endometritis and damage to the uterine epithelium and glands were found at autopsy to be less marked in suckled animals than in nonsuckled animals. Corpus luteum weight and progesterone content, studied

in cows slaughtered at 41 days post-partum, were found to be greater in E. coli inoculated animals than in those not inoculated. Absence of estrus resulting from persistence of the corpus luteum occurred only in nonsuckled inoculated animals. Both bacterial inoculation and the absence of suckling were required to maintain the corpus luteum beyond its normal life span. Persistence of the corpora lutea induced by injected gonadotropin during the early post-partum period was brought about more readily than persistence of the corpora lutea of the estrual cycle. (AH h5-6)

2. Biochemical characterization of vaginal tissue. A new microbioassay procedure for estrogens based upon the glycogen content of the rat vagina. The vagina was found to respond to estrogen in a similar fashion as the uterus with regard to glycogen content. Estrogen administration produces a marked and rapid increase in glycogen synthesis, significant increases being obtained in 3 hours. The sensitivity of this glycogenic stimulation, and possible use as a new bioassay for estrogens, was ascertained in three groups of rats: (1) Prepuberal weanling females, 21-27 days old, (2) Adult, sexually mature rats, ovariectomized to remove endogenous estrogens, and (3) Pubescent rats, ovariectomized at about the time of puberty at 40 days of age.

The intravaginal route of administration was selected as the most satisfactory method of local stimulation. In the prepuberal rats, the vagina is closed and the injections were made through the closed vaginal membranes. The trauma inherent in this method caused a variability in response so that good dose-response relationships were not attained. The procedure appeared to be sensitive to  $.001 \mu\text{g}$  estradiol, however, which is 10-20 x more sensitive than the Astwood bioassay based on uterine weight. Adult ovariectomized rats showed less variability and greater sensitivity, doses of  $.0001 \mu\text{g}$  resulting in significant increases, and  $.001 \mu\text{g}$  producing maximal stimulation in 5 hours. These dosage levels are 100-200 x more sensitive than those used in the Astwood bioassay.

The ovariectomized pubescent rats were found to be most suitable and a new microbioassay for estrogens based upon the increase in glycogen content of the vagina at 5 hours was developed. A dose of  $.000125 \mu\text{g}$  ( $125 \text{ picograms} = 125 \times 10^{-12}\text{g}$ ) of estradiol produced maximal stimulation and  $.000025 \mu\text{g}$  (25 picograms) can be detected. Estrinol was as effective as estradiol, but estrone was 10 x less active. This bioassay procedure has many advantages over previously published methods which are tedious, require multiple injections and subjective microscopic evaluation, and are much less sensitive. The vaginal glycogen response is quick, objective and technically easy to perform. (AH h5-8)

3. Role of histamine in the implantation process. Histamine release has been proposed as being responsible for the initiation of implantation. It has been claimed that pyrathiazine, an anti-histaminic drug, releases histamine in the body in a non-traumatic, physiological manner when



administered systemically. Deciduomal tissue, which is very similar to the placental tissue which develops after implantation, was induced by intraperitoneal pyrrathiazine and compared to the tissue induced by the definite injury of scratching the uterus with a barbed needle.

The permeability characteristics of the tissue induced by the two treatments was measured using trypan blue dye accumulation as a marker. A diphasic increase in permeability was noted, at 1/2 hour and 4 hours after treatment, a pattern which duplicates the typical response of general inflammation and injury. This evidence indicated that pyrrathiazine was causing deciduomata by an injurious effect on the uterus. (AH h5-8)

4. Secretion of anterior pituitary hormones and ovulation in small ruminants. The neural pathway between the hypothalamus and the pituitary is extremely important for mammary gland development as well as for normal function of the ovaries and uterus. Previous in vitro pituitary slice experiments indicated that neurosecretory substances from the hypothalamus were responsible for the release of pituitary gonadotropins. The superior median eminence of the hypothalamus was therefore extracted to isolate these substances, determine their chemical nature and study the mechanism of their action. Extracts were made with 1 N acetic acid of the lyophilized median eminence. After removal of lipids and proteins of high molecular weight, Sephadex fractionation indicated that the active fraction was a peptide of low molecular weight below 7000. This substance appeared to be the luteinizing hormone releasing factor (LHRF). When this substance was injected into rabbits, significant differences in response were found which were associated with the seasons. This seasonal variation in reactivity of rabbits to the neural factor throws some light on the sexual periodicity associated with seasons.

Surgical pituitary stalk section studies and lesion studies in the hypothalamus suggested that the release of prolactin in sheep is of an active or stimulatory nature and not of inhibitory character as has been generally accepted in rats and rabbits. (E21-AH-1)

5. Water transport through animal membranes. Influence of the pH and the ionic composition of the bathing fluids on the effect of vasopressin. This project was initiated to elucidate the mechanism of action of vasopressin (Antidiuretic hormone - ADH) on living membranes. ADH regulates the permeability of the bladder so that a more concentrated or less concentrated volume of urine is produced, according to the physiological demands of the animal. Sodium transport was measured by in vitro work on isolated toad bladder membranes suspended in a chamber containing different solutions bathing each side. The current across the membrane was dependent upon sodium transport and is responsive to ADH. Water transport was measured by weight loss of the bladder when filled and equilibrated with various solutions. The responsiveness of the toad bladder to ADH using these two experimental techniques was determined and it was found that the



minimal concentration necessary to increase sodium transport across the bladder was 300-600 times larger than that necessary to increase water transport.

The urinary flow response of hypertensive human subjects to ADH was compared to that of normotensive people during standard ADH infusion periods. Larger amounts of vasopressin (60% more) were required to reduce urine volume in hypertensive than in normals, although the amounts required were still within the physiological range. (A10-AH-17)

## 6. Hormonal control of the uterus

(a) The effect of hydrocortisone on embryo survival in sheep. Eight ewes in each of three groups were given four daily intramuscular injections of 25, 75 or 225 mg of hydrocortisone acetate (HCA), beginning 10 to 16 hours after the first detection of estrus. A greater proportion of HCA treated ewes than control ewes returned to estrus 15 to 19 days post-mating. The proportion of corpora lutea represented by viable embryos at 28 and 32 days post-mating was significantly lower in treated ewes. This loss of potential embryos was partially accounted for by advanced embryonic degeneration. Results suggest that injected hydrocortisone can suppress the fertility of ewes, and indicate a need for further investigations on the possible role of adrenal hyperactivity as a factor in lowered sheep fertility during heat stress. (AH h5-8)

(b) Effect of oxytocin administration on the oestrous cycle of unilaterally hysterectomized heifers. At Wisconsin, the effect of oxytocin administration on the oestrous cycle was studied in 16 uterine-intact and 32 surgically-prepared unicornual heifers. Unilateral hysterectomy was performed on day 3 of an oestrous cycle, and oxytocin or an equivalent volume of physiological saline, was administered daily from day 3 through day 7 or 8. Oxytocin produced significantly shorter oestrous cycles in the uterine-intact heifers and in the unicornual heifers with the retained uterine horn adjacent to the CL, but not in the unicornual heifers with the retained horn opposite to the CL. These results strongly suggest that at least part of the effect of oxytocin is exerted through local, utero-ovarian channels. A unilateral effect of the uterus on the CL was demonstrated in unicornual heifers that did not receive oxytocin. The oestrous cycles were extended and the CL persisted when the retained horn was opposite to the CL, but not when the retained horn was adjacent to the CL. (AH h5-6)

(c) Effects of hysterectomy and exogenous progesterone on the corpus luteum of the ewe. Injected progesterone exerts an inhibitory action on the developing corpus luteum of the ewe. The effect of hysterectomy on this action of progesterone was studied in 32 ewes in 4 treatment groups: (1) control, (2) progesterone-treated, (3) hysterectomized, and (4) hysterectomized and progesterone-treated. These data suggest the

possibility that a part of the action of injected progesterone on the corpus luteum of the ewe may be mediated through the uterus.

Further studies on the effects of exogenous progesterone on development of CL induced in the anestrus ewe indicated that progesterone depressed CL weights if administered during the 6 days before ovulation, whether or not progesterone was injected during the 6 days following ovulation. Post-ovulatory injection, only, was without depressing effect. (AH h5-6)

7. Surgical procedure for exteriorizing the carotid artery. In order to evaluate changes in CO<sub>2</sub> combining capacity of bovine blood under hypothermia, it is desirable to draw arterial blood with a minimum disturbance to the animal. Frequent use of either the internal iliac or prepubic arteries by rectal puncture cannot usually be accomplished without creating extensive excitement in animals. Previous techniques for exteriorizing the carotid artery involved the use of two incisions, resulting often in insufficient blood supply in the skin around the loop and the sloughing of the skin; therefore, largely unsuccessful operations. A method has been developed which involves only one skin incision. Using this technique, eight of nine operations performed were successful. After a short period of healing, the animals became accustomed to the withdrawal of blood from the loop and samples could be obtained without having to restrain the animals. The repeatability of the values using carotid blood was about twice that for blood drawn from other arteries. This technique can be used to provide a permanent loop and a more available supply of arterial blood for basic studies of blood characteristics. (AH g4-1)

8. Surgical ablation of the thymus in young calves. Removal of the cervical portion of the thymus gland in calves is a relatively easy surgical procedure, but removal of the thoracic portion without opening the thoracic cavity was unsatisfactory. Splitting the sternum also did not afford suitable access to the gland due to the depth of the thorax and the proximity of the carotid arteries to the operative field; thus, an approach through the second intercostal space was tried. This procedure has proven successful since it allowed optimum access to the thoracic portion of the gland. It is estimated that at least 97% of the total thymus gland can be safely removed. It is evident from the amount of thymus gland found at necropsy, however, that considerable growth of the residual thymus gland tissue may occur if extreme care is not taken to insure complete removal. The most likely site of the residual tissue is in the area of the thyroid gland, where it is difficult to distinguish between thymus gland tissue and fatty tissue. (AH g4-1)

9. Preservation of sperm in the hen oviduct. In Israel washed fowl spermatozoa were injected into the lumen of various ligated regions of hens' oviducts in vivo after laparotomy. They were recovered after 4 and 24 hours and their motility was compared with that of control samples kept in vitro at 18°C and 39°C.



In all regions tested, (the utero vaginal junction, the uterus, the lower, middle and upper parts of the isthmus and of the magnum) spermatozoa were capable of maintaining the motility for at least 4 hours. However, 24-hour preservation of motility was possible only in the lower part of the isthmus and in the magnum. (A10-AH-13)

10. Transaminases in the epididymal fluid of the ram. Two principal transaminases were investigated in Israel: glutamic-aspartic transaminase (GOT) and glutamic-alanine transaminase (GPT). Epididymal fluid, obtained from fistulated rams, was used for the enzyme determination. The activity of GOT was about ten times greater in the epididymal fluid and seminal plasma than in the blood serum. Almost no GPT activity was detected in the epididymal fluid and seminal plasma. These enzymes have been found in human, bovine, and rabbit seminal plasma but their presence in epididymal fluid had not been reported previously. (A10-AH-13)

11. Separation of young and old spermatozoa. Investigations at Israel have confirmed earlier work which shows that as sperm mature in their passage along the bull's reproductive tract, an increase in their specific gravity is also noted. A new column fractionation system was developed. With this technique spermatozoa were separated into two major groups, based on the differences in the specific gravity of the sperm cells. Several microscopic evaluations, at 37° C, show that the separation treatments do not harm the motility of spermatozoa. An experiment is currently underway in which cows will be bred to determine the fertilizing capacity and sex ratios of the different fractions. (A10-AH-12)

12. Zinc metabolism. Rabbit tissues were classified into three categories when Zn-65 was injected intramuscularly or intraperitoneally; (1) rapid assimilation and dispersal, (2) slow assimilation and dispersal, and (3) growing concentration. It was confirmed that Zn-65 passes the placental barrier in pregnant rabbits. Zn-65 is also found in the milk of treated, lactating rabbits. With dogs, injected Zn-65 can cause hemolytic anemia with a loss of iron. The retention of Zn-65 was higher when guinea pigs were injected intramuscularly, rather than intraperitoneally. Female guinea pigs had a higher concentration of Zn-65 than males, except in the genitalia, where males rated high. Females also excreted more Zn-65 than males. This work was done under a PL 480 project, with Spain.

#### E. Nutrition

1. Vitamin B<sub>12</sub> synthesis in the rumen. Both vitamin B<sub>12</sub> and vitamin B<sub>12</sub> analogs are produced in the rumen of the cow through synthesis by the microflora present. This represents the chief, if not the only, source of these substances for the cow. By means of electrophoresis, the positively charged vitamin B<sub>12</sub> analogs (pseudo vitamin B<sub>12</sub>, Factor A and Factor B) were separated from each other, and from the negatively charged and from the neutral analogs (including vitamin B<sub>12</sub>) in a number of samples of rumen



contents. The relative amounts present were estimated. The neutral analogs and Factor A (2-methyl adenyl cobamide) made up 85 to nearly 100% of the vitamin B<sub>12</sub> substances present, each occurring in approximately equal amounts. Vitamin B<sub>12</sub> itself made up the bulk of the neutral analog fraction. Negative analogs were either absent or present only in extremely minute amounts. Factor B (cobinamide) was present only in small amounts, when it occurred at all. Somewhat greater, but still relatively small amounts of pseudo-vitamin B<sub>12</sub> (adenyl cobamide) were found in many cases. The rumen samples were taken from cows on 4 rations--silage, chopped hay, pellets, and hay-grain. Clear-cut differences due to ration were not evident, but there was a tendency for the minor factors (Factor B, pseudo-vitamin B<sub>12</sub>) to be present in somewhat greater amounts in the samples from the cows fed silage, than from those fed the other rations. There were no marked differences attributable to time of collection of sample after feeding or to position in the rumen from which the sample was taken. The individual cow may have some, although apparently only a minor, effect on the distribution of the analogs. (AH h4-3)

2. Vitamin B<sub>12</sub> and formic acid metabolism. Work has been continued on the possible role of vitamin B<sub>12</sub> in the metabolism of formic acid, which is produced in the rumen of the cow. Formate produced impaired growth and decreased survival of rats fed vitamin B<sub>12</sub>-deficient rations. Of this substance incorporated in the ration, 7.5% was not appreciably more deleterious than 5.0%. Comparisons were made between young obtained from mothers fed a vitamin B<sub>12</sub>-deficient ration with added formate, and young from mothers fed the same B<sub>12</sub>-deficient ration but without the added formate. When the young from each lot of mothers were divided into two groups, one fed formate and the other fed no formate, differences in growth rates between the two groups were sharply reduced when the young came from the mothers fed formate. This result was apparently a consequence of (1) an interference of formate with the synthesis of vitamin B<sub>12</sub>, and (2) a partial adaption of the rat to formate so that its depressing effect on growth of vitamin B<sub>12</sub>-deficient rats was not as pronounced. The type of protein used in the B<sub>12</sub>-deficient ration also affected the action of formate. Thus, the growth depression associated with formate feeding was pronounced with rats fed casein, but significantly less with those given soy protein. Formate also had a growth-depressing action on rats fed rations containing vitamin B<sub>12</sub>. (AH h4-3)

3. Fish silage as an animal feed. Growth of chickens was improved when 5% fish "silage" was added to a ration containing toasted soy flour as the primary source of protein. (S9-AH-1)

#### F. Rumen Function

1. Growth yields of rumen bacteria. Evidence has been obtained which indicates that Bacteroides ruminicola is able to utilize glucose more efficiently than are other anaerobic bacteria. The dry weight of cells

produced during the fermentation of glucose is about 35% of the weight of the glucose supplied. This compares with 6 to 12% for most other anaerobic bacteria. Workers in England have found a similar yield with a different rumen bacterium. There is no evidence, from the Beltsville work, of the presence of energy storage compounds in B. ruminicola, indicating that the dry weight figures obtained relate to true growth efficiency. Our results and those of the English workers raise questions of fundamental interest concerning anaerobic bacteria. It is possible that rumen bacteria obtain more energy from their fermentations, or that they are more efficient in using the energy obtained therefrom than are other anaerobes. (AH h2-3)

2. Fermentation in rumen bacteria. Last year's studies indicated that B. ruminicola contains the Embden-Meyerhof system for the fermentation of glucose to pyruvate. This year methods were applied to the quantitative measurement of the individual enzymes of the Embden-Meyerhof system. In standard assays, the activities of the major enzymes of this system in B. ruminicola compared closely to the activities of the analogous enzymes in Escherichia coli. In conjunction with growth yield studies, efforts were made to study the fermentation of pyruvate by B. ruminicola since the fermentation from glucose to pyruvate appeared similar to that found in other bacteria. Thin-layer chromatographic procedures were developed for the separation of the lower molecular weight volatile fatty acids and other fermentation end-products. These procedures were used in preliminary studies of the ability of whole and broken cell preparations of B. ruminicola to metabolize radioactively labelled pyruvate. Thus far, no metabolism of pyruvate by B. ruminicola has been found. (AH h2-3)

3. Peptide utilization by Bacteroides ruminicola. B. ruminicola has been shown to take up  $^{14}\text{C}$  rapidly from uniformly labelled  $^{14}\text{C}$  L-proline-labelled peptides of molecular weights up to 2000. The uptake of peptides is temperature dependent and shows some dependence on the presence of an energy source. The initial rate of uptake seems to saturate and may exhibit Michaelis-Menten kinetics. In these respects, uptake of large peptides by B. ruminicola is similar to the uptake of small peptides by other bacteria. No peptides could be demonstrated inside the cells during uptake. The rapid appearance of free  $^{14}\text{C}$  proline indicated that peptides were hydrolyzed upon uptake. No metabolic activity of broken cell preparations towards peptides or free amino acids could be demonstrated. It is concluded that oligopeptides function only to supply amino acids to B. ruminicola in an available form, and it is postulated that this is their only function in other bacteria where oligopeptide stimulation or requirement has been found. It is postulated that B. ruminicola possesses a distinct system for the uptake of amino acids present in oligopeptides and this system does not involve extra-cellular enzymes. (AH h2-3)



PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Agricultural Chemicals

Davison, Kenneth L. 1966. Sublethal nitrate poisoning--Is it really a problem? Feed Age, March, pp. 23-27. (AH k1)

Avian Anatomy

Lucas, A. M. and Stettenheim, P. R. 1965. Avian Anatomy. chap. 1: 1-59. In Biester, H. E. and Schwarte, L. H. Diseases of Poultry. 5th edit. Iowa State Univ. Press. (AH e8-1)

Lucas, A. M. 1965. Avian anatomy project. Poultry Sci. 44: 1394. (Abs.) (AH e8-1)

Peterson, R. A., Ringer, R. K., Tetzlaff, M. J., and Lucas, A. M. 1965. Ink perfusion for displaying capillaries in the chicken. Stain Tech. 40: 351-356. (AH e8-1)

Stettenheim, P. 1965. Review of book, Avian Anatomy, by McLeod, W. M., Trotter, D. M., and Lumb, J. W. 1964. Auk 82: 664-665. (AH e8-1)

Stettenheim, P. 1966. The bristles of birds. Auk 83: 295. (AH e8-1)

Genetics

Falk, R. and Rahat, A. 1963. The dependence of viability effects caused by irradiation on the type of mating. Proc. Natl. Acad. Sci. U.S. 49: 292-298. (A10-AH-9)

Falk, R., Rahat, A. and Ben-Zeev, N. 1965. Viability of heterozygotes for induced mutations in Drosophila melanogaster. I. Irradiated X-chromosome. Mut. Res. 2: 438-451 (A10-AH-9)

Falk, R. and Ben-Zeev, N. 1966. Viability of heterozygotes for induced mutations in Drosophila melanogaster. II. Mean effects in irradiated autosomes. Genetics 53: 65-77. (AH10-AH-9)

Scheinberg, S. L. and Hierholzer, J. C. 1966. Erythrocyte antigen mosaicism in the pigeon. Symposium on the Mutational Process. Prague, Czechoslovakia. (AH p1)

Wilson, S. P., Kyle, W. H., and Bell, A. E. 1965. The effects of mating systems and selection on pupa weight in Tribolium. Genetical Research 6: 341-351. (AH p2)



Related Publications of State Experiment Stations

Becker, Walter A. and Bearnse, Gordon E. 1965. All-or-none traits and the sensitivity of experiments. *Nature* 205 (4966), p. 110. Washington.

Bohren, B. B., McKean, H. E. and Friars, G. W. 1965. The expected mean squares in genetic experiments when only one parent is identified. *Biometrics* 21 (2), p. 436. Indiana.

Datta, S. P., Stone, W. H., Tyler, W. J. and Irwin, M. R. 1965. Cattle transferrins and their relation to fertility and milk production. *J. Animal Sci.* 24 (2), pp. 313-318. Wisconsin.

Dettmers, Almut E., Rempel, W. E. and Comstock, R. E. 1965. Selection for small size in swine. *J. Animal Sci.* 24 (1), pp. 216-220. Minnesota.

Ferguson, T. M., Omar, E. M. and Couch, J. R. 1965. Muscular dystrophy in avian species. *Texas Repts. Biol. Med.* 22 (Suppl. 1), p. 902. Texas.

Haley, Leslie E. 1965. Serum albumin polymorphism in quail and chicken-quail hybrids. *Genetics* 51 (6), p. 983. California.

Krishan, Awtar, Haiden, G. J. and Shoffner, R. N. 1965. Mitotic chromosomes and the W-sex chromosome of the great horned owl. (*Bubo V. Virginianus*). *Chromosoma* 17, pp. 258-263. Minnesota.

Magee, W. T. 1965. Estimating response to selection. *J. Animal Sci.* 24 (1), pp. 242-247. Michigan.

Miller, Wilmer J. 1965. A recessive Lectin-factor in Streptopelia risoria. *Genetics* 51 (2), p. 247. Iowa.

Osterhoudt, Marjorie S. and Irwin, M. R. 1965. An embryo specific red cell antigen in a dove species, Streptopelia risoria. *Vox Sanguinis* 10, pp. 493-505. Wisconsin.

Rahnefeld, G. W., Comstock, R. E., Boylan, W. J. and Singh, Madho. 1965. Genetic correlation between growth rate and feed per unit gain in mice. *J. Animal Sci.* 24 (4), pp. 1061-1066. Minnesota.

Rausch, W. H., Ludwick, T. M. and Weseli, D. F. 1965. Determination of bovine transferrin types by disc electrophoresis. *J. Dairy Sci.* 48 (6), pp. 720-725. Ohio.

Sittman, K. and Abplanalp, H. 1965. White-feathered Japanese quail.  
J. of Hered. 56 (5), pp. 220-223. California.

Stone, W. H. and Conneally, P. M. 1965. Association between a  
blood group and butterfat production in dairy cattle. Nature 206,  
p. 115. Wisconsin.

Stone, W. H., Fenton, J. W., II Duggleby, C. R. and Otten, C. 1965.  
Isolation and fluorescent labeling of Ulex europaeus anti-H lectin.  
Vox Snaguins 10, pp. 208-211. Wisconsin.

Underkofler, Judith W. and Irwin, M. R. 1965. Further studies of  
interaction products of genes effecting cellular antigens in species  
hybrids in columbidae. Genetics 51 (6), pp. 961-970. Wisconsin.

Wilson, S. P., Kyle, W. H. and Bell, A. E. 1965. The effect of  
mating systems and selection on pupa weight in tribolium. Genet.  
Res. 6, pp. 341-351. Indiana.

Physiology

- Aiumot, Eugenia and Schindler, H. 1965. Transaminases in the epididymal fluid of the ram. J. Reprod. Fertil. 10: 261-262. (A10-AH-13)
- Aviram, A., Czaczkes, J. W., and Ullmann, T. D. 1965. Diuretic and natriuretic response to a salt load in hypertensive and prehypertensive subjects. Nephron 2: 82. (A10-AH-17)
- Bitman, J., Trezise, L. A., and Cecil, H. C. 1966. Effect of cycloheximide (actidione) on the glycogen content of the rat uterus. Arch Biochem. Biophys. 113: 414-420. (AH h5-8)
- Brinsfield, T. H., Leffel, E. C. and Hawk, H. W. 1966. Studies on induced leukocytic responses in sheep uteri. J. Animal Sci. 25: 919. (Abs.) (AH h5-8)
- Coleman, G. L., Crandall, M. L., and Guidry, A. J. 1966. Surgical ablation of the thymus gland in neonatal dairy calves. Am. J. Vet. Res. 27: 1123-1126. (AH g4-1)
- Collins, W. E., Inskeep, E. K., Howland, B. E., Pope, A. L., and Casida, L. E. 1966. Effects of hysterectomy and corpus luteum induction on pituitary-ovarian relationships in the ewe. J. Animal Sci. 25: 87-91. (AH h5-6)
- Czaczkes, J. W. and Kleeman, C. R. 1964. The effect of various states of hydration and the plasma concentration on the turnover of antidiuretic hormone in mammals. J. Clin. Invest. 43: 1649. (A10-AH-17)
- Czaczkes, J. W., Kleeman, C. R., and Koenig, M. 1964. Physiologic studies of antidiuretic hormone by its direct measurement in human plasma. J. Clin. Invest. 43: 1625. (A10-AH-17)
- Domanski, E., Mazurczak, J., and Fitko, R. 1963. The effect of the hypothalamus on the secretion and release of gonadotropic hormones by the pituitary gland in sheep. Proceedings of the 17th World-Animal Science Congress. 2/S/27. (E21-AH-1)
- Domanski, E. 1964. The effect of the hypothalamus on the secretion and release of gonadotropins by the pituitary gland. IX General Meeting of Polish Physiological Society. Acta Physiologica Polonica, 1964, XV, 5: 73. (E21-AH-1)
- Domanski, E., Mazurczak, J., Fitko, R., Przekop, F., and Kochman, K. 1964. The role of the hypothalamus in the secretion and release of gonadotropins by the adenohypophysis in sheep. 5th International Congress on Reproduction in Animals. Trento, 1964. Section II, Vol. III, 325. (E21-AH-1)



- Ginther, O. J., Woody, C. O., Mahajan, S., Janakiraman, K., and Casida, L. E. 1966. Some effects of unilateral hysterectomy and oxytocin administration in heifers. *J. Animal Sci.* 25: 923. (Abs.) (AH h5-6)
- Hawk, H. W. and Conley, H. H. 1965. Neutrophilia in the rabbit induced by hydrocortisone. *J. Animal Sci.* 24: 1217. (Abs.) (AH h5-8)
- Howarth, B., Jr., and Hawk, H. W. 1966. Effect of hydrocortisone on embryo survival in sheep. *J. Animal Sci.* 25: 924. (Abs.) (AH h5-8)
- Iranzo, J. E., Chueca, A., Junquera, S., Garcia del Amo, C., and Santo-Ruiz, A. 1965. VII. Vida media biologica del cinc en el cobayo. *R. esp. Fisiol.* 21: 165. (E25-AH-4)
- Jazdowska, B. and Dobrowolski, W. 1965. Vascularization of the hypophysis in sheep. *Endokrynologia Polska* XVI: 269-282. (E21 AH-1)
- McDowell, R. E., Underwood, P. C., Lehmann, R. H., and Barrada, M. S. Procedure for exteriorizing the carotid artery in the bovine. *J. Dairy Sci.* 49: 78-80. (AH g4-1)
- Schindler, H. and Hurwitz, S. 1966. The preservation of sperm motility in different regions of the hen oviduct in vivo. *Poultry Sci* 45: 369-374. (A10-AH-13)
- Stormshak, F., and Casida, L. E. 1965. Effects of LH and ovarian hormones on corpora lutea of pseudopregnant and pregnant rabbits. *Endocrinology* 77: 337-342. (AH h5-6)
- Stormshak, F., and Casida, L. E. 1966. Fetal-placental inhibition of LH-induced luteal regression in rabbits. *Endocrinology* 78: 887-888. (AH h5-6)
- Traczyk, W. and Przekop, F. 1963. Methods of investigation of the function of the hypothalamus and hypophysis in chronic experiments in sheep. *Acta Physiologica Polonica* Vol. XIV: 217. (E21-AH-1)
- Ullmann, T. D., Czaczkes, J. W., and Menczel, J. 1965. Modification of the antidiuretic effect of vasopressin by acid and alkaline loads. *J. Clin. Invest.* 44: 754-764. (A10-AH-17)
- Woody, C. O., Ginther, O. J., and Pope, A. L. 1966. Effects of hysterectomy and exogenous progesterone on the corpus luteum of the ewe. *J. Animal Sci.* 25: 933. (Abs.) (AH h5-6)
- Wrenn, T. R., Bitman, J., DeLauder, W. R., and Mench, M. L. 1966. Influence of the placenta in mammary gland growth. *J. Dairy Sci.* 49: 183-187. (AH h5-1)

Related Publications of State Experiment Stations

- Alliston, C. W., Howarth, B., Jr., and Ulberg, L. C. 1965.  
Embryonic Mortality Following In Vitro Culture of One- and Two-  
Cell Rabbit Eggs at Elevated Temperatures.  
J. Reprod. & Fertil. 9:337-341 N.C.
- Amann, R. P., Koefoed-Johnsen, H. H., and Levi, H. 1965.  
Excretion Pattern of Labelled Spermatozoa and the Timing of  
Spermatozoa Formation and Epididymal Transit in Rabbits Injected  
with Thymidine-3H. J. Reprod. Fertil., 10:169-183 Penn.
- Anderson, L. L. and Melampy, R. M. 1965. Mechanisms Controlling  
the Formation and Persistence of the Corpus Luteum.  
Proceedings: Conf. on Estrous Cycle Control in Domestic Animals,  
pp. 64-77, M. P. USDA 1005 Iowa
- Anderson, R. W. and Flipse, R. J. 1965. Metabolism of Glucose-C<sup>14</sup>  
by Bovine Spermatozoa.  
J. Anim. Sci. 24:913 Penn.
- Anderson, W. R. and Flipse, R. J. 1965. Asparatate-C<sup>14</sup> Metabolism  
by Bovine Spermatozoa.  
J. Dairy Science 48:805 Penn.
- Bauman, T. P., Pipes, G. W., and Turner, C. W. 1965. Relative  
Potency of Several Analogues when Substituted for L. Thyroxine  
in the Estimation of Thyroxine Secretion Rate in Rats.  
Endocrinology 76(3):537 Mo.
- Bauman, T. R. and Turner, C. W. 1965. The L-Thyroxine Secretion  
Rate, L.-Triiodothyronine Equivalent, and Biological Half-Life  
(t 1/2) of L-Thyroxine I-131 in the Raccoon (Procyon Lotor).  
Gen. & Comp. Endo. 5:261-266 Mo.



- Benson, Barbara and Schein, M. W. 1965. Factors Affecting Dust Bathing by Japanese Quail (Coturnix coturnix japonica). Amer. Zool. 5(2):196 Penn.
- Bierer, B. W., Eleazer, T. H., and Roebuck, D. E. 1965. Effect of Feed and Water Deprivation on Chickens, Turkeys, and Laboratory Mammals. Poul. Sci. Vol. 44, No. 3, pp. 768-773 S.C.
- Clegg, M. T., Cole, H. H. and Ganong, W. F. 1965. The Role of Light in the Regulation of Cyclical Estrous Activity in Sheep. Proc. Conf. on Estrous Cycle Control in Domestic Animals, pp. 96-103. Calif.
- Cragle, R. G., Miller, J. K., Swanson, E. W., and Brown, D. G. 1965. Lactation and Radionuclide Metabolism Responses of Dairy Cattle to Lethal Doses of Gamma and Neutron Radiation. J. Dairy Sci. 48:942. Tenn.
- Dietz, R. W. and Flipse, R. J. 1965. Glycine Transport by Bovine Spermatozoa. J. Dairy Science 48:806 Penn.
- Djojoseobagio, S. and Turner, C. W. 1965. Effect of Sodium Citrate on Milk Yield in Rats. Proc. Soc. Exp. Biol. Med. 117:557 Mo.
- Donaldson, Lloyd E., Hansel, William, and VanVleck, L. D. 1965. The Luteotropic Properties of Luteinizing Hormone and the Nature of Oxytocin Induced Luteal Inhibition in Cattle. J. Dairy Sci. 48:331-337 N.Y.
- Duby, R. T., McDaniel, J. W. and Black, D. L. 1965. Homotransplantation of the Hamster Uterus. Nature 205 (4972):720 Mass.
- Dziuk, P. 1965. Response of Sheep and Swine to Treatments for Control of Ovulation. CSRS, ARS, M. P. 1005, pp. 50-57 Ill.
- Dziuk, P. and Dickmann, Z. 1965. Failure of the Zona Reaction in Five Pig Eggs. Nature 208:502 Ill.
- Eleftheriou, B. E. and Zolovick, A. J. 1965. An Atlas of the Forebrain of P.m. bairdii in Stereotaxic Coordinates. Kansas Agr. Exp. Sta. Tech. Bul. No. 146 Kans.

- Erickson, B. H. 1965. Symposium on Atomic Energy in Animal Science: Radiation Effects on Gonadal Development in Farm Animals.  
J. Anim. Sci. 24:568-583 Tenn.
- Frankel, A. I., Gibson, W. R., Graber, J. W., Nelson, D. M., Reichert, L. E., Jr., and Nalbandov, A. V. 1965. An Ovarian Ascorbic Acid Depleting Factor in the Plasma of Adenohypophysectomized cockerels.  
Endocrinology 77:651 Ill.
- Gangwar, P. C., Branton, C. and Evans, D. L. 1965. Reproductive and Physiological Responses of Holstein Heifers to Controlled and Natural Climatic Conditions.  
J. Dairy Sci. 48:222-228 La.
- Gomes, W. R. and Erb, R. E. 1965. Progesterone in Bovine Reproduction: A Review.  
J. Dairy Sci. 48:314-330 Ind.
- Gomes, W. R., Mellin, T. N. and Erb, R. E. 1965. Comparison of Methods for Hydrolysis of Bovine Urinary Estrogen Conjugates.  
J. Dairy Sci. 48:493-494 Ind.
- Grossie, J. and Turner, C. W. 1965. Effect of Thyroparathyroidectomy and Adrenalectomy on Food Intake in Rats.  
Proc. Soc. Exp. Biol. Med. 118:25-27 Mo.
- Grossie, J. and Turner, C. W. 1965. Effect of Thyroxine Hydrocortisone and Growth Hormone on Food Intake.  
Proc. Soc. Exp. Biol. Med. 118:28-30 Mo.
- Hafez, E. S. E., Estergreen, V. L. and Foster, R. J. 1965. Progestins and Nucleic Acids Content of Corpora Lutea During Multiple Pregnancy.  
ACTA Endocrinologica 48:664-672 Wash.
- Hahn, D. W., Ishibashi, T. and Turner, C. W. 1965. Effect of Hypophysectomy on Feed Intake in Rats.  
Proc. Soc. Exp. Biol. Med. 119-1238 Mo.
- Hahn, E. W. and Hays, R. L. 1965. Modification of the Incidence of Mating in Rats by Stimulation with a Short Air Blast.  
Psych. Rep. 16:862-864 Ill.
- Hahn, S. W. and Turner, C. W. 1965. Effect of Alloxan on Lactation and on Replacement Therapy with Insulin in the Rat.  
Proc. Soc. Exp. Biol. Med. 119-1133 Mo.



- Hays, R. L., Hahn, E. W. and Kendall, K. A. 1965. Evidence for Decreased Steroidogenesis in Pregnant Rats Fed a Sucrose Diet. *Endocrinology* 76:771-772 Ill.
- Hendrich, C. E. and Turner, C. W. 1965. Effect of 1-Methyl-2-Mercaptomidazole (Methiamazole-tapazole) on Food Consumption in the Rat. *Proc. Soc. Exp. Biol. Med.* 119-174 Mo.
- Henricks, D. M. and Mayer, D. T. 1965. Characterization of the Basic Protein Associated with DNA in Mammalian Spermatozoa. *Proc. Soc. Expt. Biol. & Med.* 119:769. Mo.
- Henricks, D. M. and Mayer, D. T. 1965. Isolation and Characterization of a Basic Keratin-Like Protein from Mammalian Spermatozoa. *Exptl. Cell Res.* 40:402-412 Mo.
- Howarth, B., Jr., Alliston, C. W. and Ulberg, L. C. 1965. Importance of Uterine Environment on Rabbit Sperm Prior to Fertilization. *J. Anim. Sci.* 24:1027-1032 N.C.
- Hsu, R. Y., Wasson, Gertrude and Porter, J. W. 1965. The Purification and Properties of the Fatty Acid Synthetase of Pigeon Liver. *J. Biol. Chem.* 240(10), p. 3736 Wisc.
- Jara Almonte, Marcial, Meyers, R. M. and Nelson, L. A. 1965. Semen Stored in NJ-1 with Added PVP. *J. Anim. Sci.* 24:288 N.C.
- Johnson, A. Doyle and Ulberg, L. C. 1965. Some Physiological Manifestations in the Bovine Estrous Cycle During Control with Exogenous Hormones. *J. Anim. Sci.* 24:403-407 N.C.
- Johnson, H. D. 1965. Response of Animals to Heat. *Meteorological Monographs.* 6(28):109-122 Mo.
- Kennelly, J. J. and Foote, R. H. 1965. Superovulatory Response of Pre- and Post-Pubertal Rabbits to Commercially Available Gonadotrophins. *J. Reprod. Fertil.* 9:177-188 N.Y.
- Kibler, H. H. 1965. Mercury Avoidance in Collecting and Displacing Gas Samples. *J. Dairy Sci.* 48:405-406 Mo.
- Kirton, K. T. and Hafs, H. D. 1965. Sperm Capacitation by Uterine Fluid or Beta-Amylase In Vitro. *Science* 150-618 Mich.

- Kragt, C. L. and Meites, J. 1965. Stimulation of Pigeon Pituitary Prolactin Release by Pigeon Hypothalamic Extract In Vitro.  
Endocrinology 76:1169-1176 Mich.
- Kumaresan, P. and Turner, C. W. 1965. Effect of Alloxan on Feed Consumption in Rats.  
Proc. Soc. Exp. Biol. Med. 119-400 Mo.
- Kumaresan, P. and Turner, C. W. 1965. Effect of Graded Levels of Insulin on Lactation in the Rat.  
Proc. Soc. Exp. Biol. Med. 119-415 Mo.
- Kumaresan, P. and Turner, C. W. 1965. Effect of Growth Hormone and Thyroxine on Mammary Gland Growth in the Rat.  
J. Dairy Sci. 48:592 Mo.
- Kumaresan, P. and Turner, C. W. 1965. Effect of Insulin and Alloxan on Mammary Gland Growth in Rats.  
J. Dairy Sci. 48:1378 Mo.
- Larson, B. L. 1965. Biosynthesis of the Milk Proteins (Review Article)  
J. Dairy Sci. 48(1):133-139 Ill.
- Larson, B. L. and Hageman, E. C. 1965. Apparent Immunological Similarity of Bovine  $\beta$ -Lactoglobulins A, B, and C.  
J. Dairy Sci. 48(8):1111-1112 Ill.
- Larson, B. L., et. al. 1965. Preparation of Specifically Labeled Milk Proteins Using Bovine Mammary-Cell Cultures.  
Biochem. Biophys. Acta. 104:462-469 Ill.
- Leavitt, W. W. 1965. Relative Effectiveness of Estradiol and Coumestrol on the Reversal of 'Castration Changes in the Anterior Pituitary of Mice.  
Endocrinology 77:247-254 N.H.
- Lepkovsky, S., Lemmon, R. M., Chari-Bitron, A. and Dimick, M. K. 1965. The Rate of the Conversion of Acetate-2-C<sup>14</sup> to Lipids as A Measure of the Synthetic Activity of Tissues During the Digestive Process. In Radioisotopes in Animal Nutrition and Physiology. International Atomic Energy Agency, Vienna, pp. 145-156 Calif.
- Lynn, J. E., Collins, W. E., Inskeep, E. K., McShan, W. H. and Casida, L. E. 1965. Effects of Gonadotropins, Oxytocin and Glucose on the Bovine Corpus Luteum at the Fourteenth Day of the Estrual Cycle.  
J. Anim. Sci. 24:790-794 Wisc.



- Malven, P. V. and Hansel, W. 1965. The Effect of Bovine Endometrial Extracts, Vasopressin and Oxytocin on the Duration of Pseudo-Pregnancy in Hysterectomized and Intact Rats.  
J. Reprod. and Fertil. 9:207-215 N.Y.
- Marshall, R. T. and Mishra, B. N. 1965. Influence of Blood Serum on Growth of Corynebacterium Bovis in Skimmilk and Trypticase Soy Broth.  
J. Dairy Sci. 48(7):881 Mo.
- Marx, G. D. and Cole, C. L. 1965. Histological Study of the Mammary Gland to Determine Origin of Specific Gamma Globulin Secretion in Milk.  
J. Dairy Sci. 48:801 Minn.
- Mather, F. B., Wilson, W. O. and Woard, A. E. 1965. Systems for Recording Time of Oviposition in Chicken, Turkey and Quail.  
Poul. Sci. 44(4), pp. 1100-1104 Calif.
- Mathey, W. J. 1965. Avian Tracheal Rings.  
Poultry Sci. 44(6):1465-1467 Wash.
- Mathis, R. Morrell and Foote, W. C. 1965. Effects of Estradiol, LH and Hysterectomy on Rabbit Corpora Lutea.  
J. Anim. Sci. 24:925 Utah
- McCormick, Donald B. 1965. Specific Purification of Avidin by Column Chromatography on Biotin-Cellulose.  
Anal. Biochem. 13(2):194 N.Y.
- McFarland, L. Z., Martin, K. D. and Freedland, R. A. 1965. The Activity of Selected Soluble Enzymes in the Avian Nasal Salt Gland.  
J. Cell. & Comp. Physiol. 65(2):237 Calif.
- McFarland, L. Z. and Wilson, W. O. 1965. A Stereotaxic Instrument for Small Birds.  
Poul. Sci. 44(2):548-549 Calif.
- McFee, A. F., Murphree, R. L. and Reynold, R. A. 1965. Skeletal Defects in Prenatally Irradiated Sheep, Cattle and Swine.  
J. Anim. Sci. 24:1131 Tenn.
- Meites, J. 1965. Maintenance of the Mammary Lobulo-Alveolar System in Rats After Adreno-Orchidectomy by Prolactin and Growth Hormone.  
Endocrinology 76:1220-1223 Mich.

- Meites, J. and Fiel, N. J. 1965. Effect of Starvation on Hypothalamic Content of "Somatotropin Releasing Factor" and Pituitary Growth Hormone Content.  
Endocrinology 77:455:460 Mich.
- Miller, L. D. and Mayer, Dennis T. 1965. Lipid Classes of Bovine Spermatozoa.  
J. Dairy Sci. 48:395 Mo.
- Mellin, T. N. and Erb, R. E. 1965. Estrogens in the Bovine: A Review.  
J. Dairy Sci. 48:687-700 Ind.
- Mellin, T. N., Erb, R. E. and Estergreen, V. L. 1965. Quantitative Estimation and Identification of Estrogens in Bovine Urine.  
J. Dairy Sci. 48:895-902 Ind. & Wash.
- Mittal, K. K., Salisbury, G. W., Graves, C. N. and Rasmusen, B. A. 1965. Antigens of Bovine Semen and the Influence of Specific Rabbit Anti-Bull Semen Serum on Metabolic Activity of Bull Spermatozoa.  
J. Reprod. Fertil. 10:29-34 Ill.
- Morrill, J. L., Farmer, E. L. 1965. A Comparison of Analytical Methods for Determination of Bovine Blood Carbohydrate.  
J. Dairy Sci. 48:818 Kans.
- Nellor, John E. 1965. The Leucocyte-Like Cells of the Oviducts During the Normal Estrous Cycle and their Modification by Progesterin and Estrogen Treatment.  
The Anat. Rec. 151:171-181 Mich.
- Nelson, D. M., Norton, H. W. and Nalbandov, A. V. 1965. Hypophysial and Plasma LH Levels in Intact and Castrate Cockerels.  
Endocrinology 77:731 Ill.
- Patrick, Homer, Emerson, R. E. and Hyre, H. M. 1965. Design and Usage of a Cs<sup>137</sup> Gamma Irradiator for Breeding and Physiological Studies. West Virginia Agr. Expt. Sta. Bul. 518T, W. Va.
- Preston, R. L., Martin, J. E., Blakely, J. E. and Pfander, W. H. 1965. Structural Requirements for the Growth Response of Certain Estrogens in Ruminants.  
J. Anim. Sci. 24(2):338-340 Mo.
- Ratner, A., Talwaker, P. K. and Meites, J. 1965. Effects of Reserpine on Prolactin-Inhibiting Activity of Rat Hypothalamus.  
Endocrinology 77:315-319 Mich.



- Reineke, E. P. 1965. Influence of Goitrogens on I<sup>131</sup> Turnover  
in Thyroids of Thyroxine-Treated Rats.  
The Physiologist 8:257 Mich.
- Ryan, C. A. and Tomimatsu, Y. 1965. A Crystalline Avian Pancreatic  
Protein.  
Arch. Biochem. & Biophys. 111(2):461 Wash.
- Schomberg, D. W., Featherston, W. R. and Erb, R. E. 1965.  
Excretion of Metabolites of Progesterone-4<sup>14</sup>C in the Cycling  
Sow.  
J. Animal Sci. 24:1195 Ind.
- Schultze, A. B. 1965. Litter Size and Proportion of Females in  
The Offspring of Multiparous Rats with Varying Uterine Metabolic  
Levels.  
J. Reprod. & Fertil. 10:145 Nebr.
- Shelton, Maurice and Morrow, John T. 1965. Effect of Season on  
Reproductive Performance of Rambouillet Ewes.  
J. Anim. Sci. 24:795-799 Tex.
- Simmons, K. R., Dracy, A. E. and Essler, W. O. 1965. Diurnal  
Temperature Patterns in Unrestrained Cows.  
J. Dairy Sci. 48:1490 Vt.
- Simmons, K. R., Dracy, A. E. and Essler, W. O. 1965. Recording  
Uterine Activity by Radio Telemetry Techniques.  
J. Dairy Sci. 48:1126 Vt.
- Sinha, D. and Meites, J. 1965/1966. Effects of Thyroidectomy and  
Thyroxine on Hypothalamic Concentration of Thyrotropin Releasing  
Factor and Pituitary Content of Thyrotropin in Rats.  
Neuroendocrinology 1:4-14 Mich.
- Sittman, K. and Abplanalp, H. 1965. Duration and Recovery of  
Fertility in Japanese Quail (Coturnix coturnix japonica).  
British Poul. Sci. 6(3):245-250 Calif.
- Smith, Robert C. and Salmon, W. D. 1965. Enhancement by Adenine  
of the Inhibition of Salmonella typhimurium by Ethionine.  
J. Bacteriol. 89(6):1494 Ala.
- Smith, S. C., Stout, R. G., Dunlop, W. R. and Smith, E. C. 1965.  
Fatty Acid Composition of Cultured Aortic Cells from White Carneau  
and Show Racer Pigeons.  
J. Atherosclerosis Res. 5(4):379 N.H.

- Stallcup, O. T. 1965. Acid and Alkaline Phosphatase Activity in Bovine Semen as Related to Fertility.  
J. Dairy Sci. 48:752-754 Ark.
- Stormshak, F. and Casida, L. E. 1965. Effects of LH and Ovarian Hormones on Corpora Lutea of Pseudopregnant and Pregnant Rabbits.  
Endocr. 77:337-342 Wisc.
- Stufflebeam, C. E., Mayer, D. T. and Lasley, J. F. 1965. Hemoglobin Resistance in Dwarf and Normal Cattle.  
J. Heredity 56:181 Mo.
- Swanson, E. W., Cragle, R. G. and Miller, J. K. 1965. Effects of Irradiation upon Lactation.  
J. Dairy Sci. 48:563 Tenn.
- Swierstra, E. E. and Foote, R. H. 1965. Duration of Spermatogenesis and Spermatozoan Transport in the Rabbit Based on Cytological Changes, DNA Synthesis and Labeling and Tritiated Thymidine.  
Am. J. Anat. 116:401-412 N.Y.
- Tanaka, Katuhide, Mather, F. Benjamin, Wilson, Wilbur O. and McFarland, Larry Z. 1965. Effect of Photoperiods on Early Growth of Gonads and on Potency of Gonadotropins of the Anterior Pituitary in Coturnix.  
Poul. Sci. 44(3):662-665 Calif.
- Ullrey, D. E., Sprague, J. I., Becker, D. E. and Miller, E. R. 1965. Growth of the Swine Fetus.  
J. Anim. Sci. 24:711 Mich.
- Weeth, H. J. and Lesperance, A. L. 1965. Renal Function of Cattle Under Various Water and Salt Loads.  
J. Anim. Sci. 24:441 Nev.
- Welch, P. R. and Murphree, R. L. 1965. Effects of Chronic Irradiation on Sperm Production by Bulls.  
J. Anim. Sci. 24:1045 Tenn.
- Williams, W. F., Lynch, J., Teama, Z. and Barens, M. 1965. Identification of Steroids in Bovine Tissue Using Thin-Layer and Gas Chromatographic Techniques.  
J. Dairy Sci. 48:814 Md.
- Williams, W. F., Weisshaar, A. F. and Lauterbach, G. E. 1965. Lactogenic Hormone Effects on Plasma NEFA and Blood Glucose Concentrations.  
J. Dairy Sci. 28:801 Md.



Yousef, M. K. and Johnson, H. D. 1965. Helmet for Continuous  
Sampling of Exhaled Air of Cattle.

J. Dairy Sci. 48:104-106

Mo.

Yousef, M. K. and Johnson, H. D. 1965. Some Blood Constituents of  
Dairy Cattle: Influence of Thyroxine and High Environmental  
Temperature.

J. Dairy Sci. 48:8, 1074-1078

Mo.

Yousef, M. K. and Johnson, H. D. 1965. Time Course of Thyroxine  
 $I^{131}$  Disappearance Rates in Cattle During Exposure to Hot and  
Cold Environments.

Life Science 4:1531-1543

Mo.

Nutrition

Corengia, C., Bertullo, V. H. and Alvarez, C. 1965. El Ensilado de pescado como complementador de la harina de soyz, en la alimentaction de pollos parrilleros. Apartado Revista Inst. Invest. Pesqueras 1(4): 315. (S9-AH-1)

Hartman, A. M. and Dryden, L. P. 1965. Vitamins in milk and milk products. A review booklet; American Dairy Science Assoc., 121 pp. November 1965. (AH h4-3)

Rumen Function

Pittman, K. A. 1966. Oligopeptide uptake by Bacteroides ruminicola. Ph.D. Thesis, University of Maryland. (AH h2-3)



Related Publications of State Experiment Stations

- Ammerman, C. B., Harms, R. H., Dennison, R. A., Arrington, L. R. and Loggins, P. E.  
Dried Tomato Pulp, Its Preparation and Nutritive Value for Livestock and Poultry.  
Fla. Agr. Exp. Sta. Bul. 691. Florida
- Arrington, L. R., Taylor, R. N., Ammerman, C. B., and Shirley, R. L. 1965.  
Effects of Excess Dietary Iodine Upon Rabbits, Hamsters, Rats and Swine.  
J. Nutrition 87(4):394-398. Florida
- Baldwin, R. L. 1965.  
Pathways of Carbohydrate Metabolism in the Rumen. In Physiology of Digestion in the Ruminant.  
Butterworths, Inc., Washington, D. C. California
- Baldwin, R. L., and Milligan, L. P. 1965.  
Electron Transport in Peptostreptococcus elsdenii.  
Biochim. Biophys. Acta. 92:421-432. California
- Baldwin, R. L. and Palmquist, D. L. 1965.  
Effect of Diet on the Activity of Several Enzymes in Extracts of Rumen Microorganisms.  
Applied Microbiology 13(2):194-200. California
- Barnes, R. F. 1965.  
The Use of In Vitro Rumen Fermentation Techniques for Estimating Forage Digestibility and Intake.  
Agron. J. 57:213-216. Indiana
- Bell, T. A., Etchells, J. L. and Smart, W. W. G. Jr. 1965.  
Pectinase and Cellulase Enzyme Inhibitor From Sericea and Certain Other Plants.  
Botanical Gazette 12:40-45. North Carolina
- Blincoe, C., Bohman, V. R. and Fountain, E. L. 1965.  
Cattle as Fallout Monitors. Cesium-137 Concentrations in Desert Range Cattle.  
Agr. and Food Chem. 13(2):157-163. Nevada
- Bloomfield, R. A., Guyon, J. C., and Murmann, R. K. 1965.  
Suggested Rapid Method for Nitrate With Rhenium and Synphenyl-2-pyridyl Ketoxine.  
J. AWWA (American Water Works Assoc.) 57:935-937. Missouri
- Bone, J. F., Roffler, S. A., and Weswig, P. H. 1965.  
Incidence and Histopathology of Calcinosis in Cotton Rats.  
Lab. Animal Care 15:81-93. Oregon

- Borchers, R. 1965.  
Proteolytic Activity of Rumen Fluid In Vitro.  
J. Anim. Sci. 24(4):1033-1038. Nebraska
- Borchers, R. 1965.  
Environmental Temperature and Growth Inhibition of Weanling Rats Fed Soybean Ration.  
J. Nutrition 85:205-206. Nebraska
- Borchers, R., Anderson, S. M. and Spelts, J. 1965.  
Rate of Respiratory Carbon-14 Dioxide Excretion After Injection of C<sup>14</sup>-Amino Acids in Rats Fed Raw Soybean Meal.  
J. Nutrition 86:253-255. Nebraska
- Byrd, C. A., and Matrone, G. 1965.  
Investigations of Chemical Basis of Zinc-Calcium-Phytate Interaction in Biological Systems.  
Proc. Soc. Exptl. Biol. Med. 119:347-349. North Carolina
- Carter, M. W., Matrone, G., and Metzler, C. 1965.  
Estimation of the Life Span of Red Blood Cells in the Growing Animal in Different Nutritional States.  
J. General Physiol. 49:57-67. North Carolina
- Charkey, L. W., Hougham, Duane F., and Kano, Adeline K. 1965.  
Relationship of Blood and Liver Levels of Glutathione to Early Growth of Chicks.  
Poul. Sci. 44(2):186-192. Colorado
- Chiemchaisri, Y. and Phillips, P. H. 1965.  
Certain Factors Including Fluoride Which Affect Magnesium Calcinosis in the Dog and Rat.  
J. Nutrition 86:23-28. Wisconsin
- Chung, R. A., Rogler, J. C. and Stadelman, W. J. 1965.  
The Effect of Dietary Cholesterol and Different Dietary Fats on Cholesterol Content and Lipid Composition of Egg Yolk and Various Body Tissues.  
Poultry Sci. 44(2):221-228. Indiana
- Connor, W. E., Osborne, J. W., and Marion, W. L. 1965.  
Incorporation of Plasma Cholesterol-4-C<sup>14</sup> into Egg Yolk Cholesterol.  
Proc. Soc. Exptl. Biol. and Med. 118(3):710-713. Iowa
- Danke, R. J. and Tillman, A. D. 1965.  
Effect of Free Gossypol and Supplemental Dietary Iron on Blood Constituents of Rats.  
J. Nutrition 87:493-498. Oklahoma
- Danke, R. J. and Tillman, A. D. 1965.  
Effect of Gossypol and Hexahomoserine on Performance of Rats Fed Purified Diets With and Without Lysine.  
J. Anim. Sci. 24(1):131-134. Oklahoma



- Darwish, N. M. and Kratzer, F. H. 1965.  
Metabolism of Ethylenediaminetetraacetic Acid (EDTA) by Chickens.  
J. Nutrition 86(2):187-192. Colorado
- Dehority, B. A. 1965.  
Degradation and Utilization of Isolated Hemicellulose by Pure Cultures of  
Cellulolytic Rumen Bacteria.  
J. Bacteriology 89:1515-1520. Ohio
- Desai, I. D., and Scott, M. L. 1965.  
Mode of Action of Selenium in Relation to Biological Activity of  
Tocopherols.  
Arch. Biochem. Biophys. 110(2):309-315. New York
- Driever, C. W., Christian, J. E., Bosquet, W. F., Plumlee, M. P. and  
Andrews, F. N. 1965.  
Iodine 131 Retention in Calves.  
J. Dairy Sci. 48(8):1088-1090. Indiana
- Ellis, W. C., and Pfander, W. H. 1965.  
Rumen Microbial Polynucleotide Synthesis and Its Possible Role in  
Ruminant Nitrogen Utilization.  
Nature 205:974. Missouri
- El-Shazly, K., and Hungate, R. E. 1965  
Fermentation Capacity as a Measure of Net Growth of Rumen Microorganisms.  
Appl. Microbiol. 13:61-69. Colorado
- Emerick, R. J., Embry, L. B. and Seerley, R. W. 1965.  
Rate of Formation and Reduction of Nitrite-Induced Methemoglobin in Vitro  
and in Vivo as Influenced by Diet of Sheep and Age of Swine.  
J. Animal Sci. 24(1):221-230. South Dakota
- Evans, J. L., Arroyo-Aguilu, J., Taylor, M. W., and Ramage, C. H. 1965.  
Date of Harvest of New Jersey Forages as Related to the Nutrition of  
Ruminant Animals.  
N. J. Agr. Exp. Sta. Bull. 814. New Jersey
- Evans, L., Patton, S., McCarthy, R. D. and Holter, J. B. 1965.  
Metabolism of Tripalmitin-1-C<sup>14</sup>-Labeled Serum Low-Density Lipoproteins by  
the Isolated Perfused Goat Liver.  
J. Dairy Sci. 48(1):44-50. Pennsylvania
- Fisher, H. 1965.  
Variations in the Urinary Creatinine Excretion of Rats Fed Diets With  
Different Protein and Amino Acid Content.  
J. Nutrition 85(2):181-186. New Jersey
- Fisher, H., and Kaunitz, H. 1965.  
Dietary Saturated Medium-Chain Triglycerides and Vitamin E Deficiency in  
Chicks and Rats.  
Proc. Soc. Exptl. Biol. and Med. 120(1):175-179. New Jersey



- Forbes, R. M. 1965.  
Mineral Utilization in the Rat. V. Effects of Dietary Thyroxine on  
Mineral Balance and Tissue Mineral Composition With Special Reference  
to Magnesium Nutriture.  
J. Nutrition 86:193-200. Illinois
- Griminger, P. 1965.  
Vitamin K Activity in Chickens:Phylloquinone and Menadione in the Presence  
of Stress Agents.  
J. Nutrition 87(3):337-343. New Jersey
- Grove, John A., Johnson, Ralph M., and Cline, Jack H. 1965.  
Vitamin E Deficiency in the Rat. I. Effect of Substrate Concentration  
on Respiratory Decline in Liver Homogenates From Rats Fed a Vitamin E-  
Deficient Diet.  
Arch. Biochem. Biophy. 110(2):357-364. (The Ohio State Univ., Columbus)
- Henderson, T. O., McNeill, J. J. and Tove, S. B. 1965.  
Folic Acid Involvement in Cyclopropane Fatty Acid Synthesis in Lactobacilli.  
J. Bacteriology 90:1283-1287. North Carolina
- Heth, D. A. and Hoekstra, W. G. 1965.  
Zinc-65 Absorption and Turnover in Rats. I. A Procedure to Determine  
Zinc-65 Absorption and the Antagonistic Effect of Calcium in a  
Practical Diet.  
J. Nutrition 85(4):367-374. Wisconsin
- Hogg, R. W., Biswas, C. S., and Broquist, H. P. 1965.  
Interference With Valine and Isoleucine Biosynthesis by Cyclic  
Hydroxamic Acids.  
J. Bact. 90:1265-1270. Illinois
- Hungate, R. E. 1965.  
The Rumen and Its Microbes  
Academic Press. New York. California
- Hungate, R. E. 1965.  
Measurement of the Rumen Fermentation. pp. 311-321.  
In Physiology of Digestion in the Ruminant, Daugherty, ed., Butterworths,  
London and Washington. California
- Ifkovits, R. W., Ragheb, H. S., Barnes, R. F., and Packett, L. V. 1965.  
A Pure-Culture Inoculum Method for Evaluation of Forage Cellulose  
Digestibility.  
J. Animal Sci. 24(4):1092-1099. California
- Ingalls, J. R., Thomas, J. W. and Tesar, M. B. 1965.  
Comparison of Responses to Various Forages by Sheep, Rabbits and Heifers.  
J. Animal Sci. 24(4):1165-1168. Michigan

- Johnson, R. J., and Dyer, I. A. 1965.  
A Comparison of Serum-L-Aspartate:2-Oxoglutarate Aminotransferase  
Activity in the Normal and Tympanitic Bovine.  
Life Sci. 4:1263-1266. Washington
- Kagawa, T., Wilken, D. R. and Lardy, H. A. 1965.  
Control of Choline Oxidation in Liver Mitochondria by Adenine Nucleotides.  
J. Biol. Chem. 240:1836-1842. Oklahoma
- Kahn, B., Jones, I. R., Carter, M. W., Robbins, P. J. and Straub, C. P. 1965.  
Relation Between Amount of Cesium<sup>137</sup> in Cow's Feed and Milk.  
J. Dairy Sci. 48(5):556-562. Oregon
- Kahn, B., Jones, I. R., Porter, C. R. and Straub, C. P. 1965.  
Transfer of Radiostrontium From Cows' Feed to Milk.  
J. Dairy Sci. 48(8):1023-1030. Oregon
- Kakade, M. L. and Evans, R. J. 1965.  
Nutritive Value of Navy Beans (Phaseolus vulgaris).  
Brit. J. Nutr. 19(2):269-276. Michigan
- Kakade, M. L. and Evans, R. J. 1965.  
Growth Inhibition of Rats Fed Navy Bean Fractions.  
J. Agr. Food Chem. 13(5):405-407. Michigan
- Kakade, M. L., Keahey, K. K., Whitehair, C. K., and Evans, R. J. 1965.  
Morphological Changes in Rats Fed Navy Beans.  
Proc. Soc. Exptl. Biol. and Med. 119(4):934-937. Michigan
- Keating, E. K., Saba, W. J., Hale, W. H. and Taylor, B. 1965.  
Further Observations on the Digestion of Milo and Barley by Steers and  
Lambs.  
J. Animal Sci. 24(4):1080-1085. Arizona
- King, K. W. 1965.  
Enzymatic Attack on Highly Crystalline Hydrocellulose.  
J. Ferment. Tech. 43:79-94. Virginia
- Kokatnur, M. G., Bergan, J. G., and Draper, H. H. 1965.  
A Rapid Method for the Preparation of Peroxides From Autoxidized Methyl  
Esters of Fatty Acids.  
Anal. Biochem. 12:325-331. Illinois
- Leach, R. M., Jr., and Nesheim, M. C. 1965.  
Nutritional, Genetic and Morphological Studies of an Abnormal Cartilage  
Formation in Young Chicks.  
J. Nutrition 86(3):236-244. New York
- Leatherwood, J. M. 1965.  
Cellulase From Ruminoccus albus and Mixed Microorganisms.  
Applied Microbiol. 13:771-775. North Carolina



- Li, L. H., Flora, R. M. and King, K. W. 1965.  
Individual Role of Cellulase Components Derived From Trichoderma viride.  
Arch. Biochem. Biophys. 111:434-447. Virginia
- Likuski, H. J. A. and Forbes, R. M. 1965.  
Mineral Utilization in the Rat. IV. Effects of Calcium and Phytic Acid  
on the Utilization of Dietary Zinc.  
J. Nutrition 85:230-234. Illinois
- Mah, R. A., and Hungate, R. E. 1965.  
Physiological Studies on the Rumen Ciliate, Ophryoscolex purkynei Stein.  
J. Protozool. 12:131-136. Colorado
- Margen, S., and Tarver, H. 1965. Colorado  
The Preparation of Labeled Albumin for Turnover Studies.  
In Advances in Tracer Methodology. Vol. II. Plenum Press. New York.
- Mathias, M. M., Allaway, W. H., Hogue, D. E., Marion, M. V. and  
Pardner, R. W. 1965.  
Value of Selenium in Alfalfa for the Prevention of Selenium Deficiencies  
in Chicks and Rats.  
J. Nutrition 86:213-219. New York
- McDonald, B. E., and Johnson, B. C. 1965.  
Metabolic Response to Realimentation Following Chronic Starvation in the  
Adult Male Rat.  
J. Nutrition 87:161-167. Illinois
- McGilliard, A. D., Jacobson, N. L., and Sutton, J. D. 1965.  
Physiological Development of the Ruminant Stomach. Iowa  
In Physiology of Digestion in the Ruminant. Butterworth, Inc. Washington.
- Miller, G. J., and Ellis, W. W. 1965.  
Effects of Dietary Lipid and Diethylstilbestrol Upon Liver Fatty Acids  
of Choline-Deficient Rats.  
J. Nutrition 86:399-405. Wyoming
- Miller, W. J., Morton, J. D., Pitts, W. J. and Clifton, C. M. 1965.  
Effect on Zinc Deficiency and Restricted Feeding on Wound Healing in the  
Bovine.  
Proc. Soc. Exptl. Biol. Med. 118:427-430. Georgia
- Miller, W. J., Powell, G. W., Pitts, W. J., and Perkins, H. F. 1965.  
Factors Affecting Zinc Content of Bovine Hair.  
J. Dairy Sci. 48(8):1091-1095. Georgia
- Morrill, J. L., Jacobson, N. L., McGilliard, A. D., and Hotchkiss, D. K.  
1965.  
Use of a Re-entrant Ileal Fistula to Study Carbohydrate Utilization by the  
Young Bovine.  
J. Nutrition 85:429-437. Illinois



- Moury, D. N., Crane, F. L., and Rogler, J. C. 1965.  
Effects of Dietary Iodinated Casein on Components of the Electron Transport  
System of Chicken Liver.  
Proc. Soc. Exptl. Biol. Med. 118(3):776-779. Indiana
- Naber, E. C., Scott, K. and Johnson, R. M. 1965.  
Effect of Calcium on the Incorporation of Proline into Hydroxyproline  
of Collagen Fractions From Normal and Lathyrotic Chick Embryos.  
Poultry Sci. 44(6):1540:1545. Ohio
- Naber, E. C., and Largent, E. J. 1965.  
Thalidomide Teratogenesis in the Developing Chick Embryo and Its  
Relationship to Vitamin Metabolism.  
Poultry Sci. 44(6):1583-1591. Ohio
- Norman, A. W. 1965.  
Actinomycin D and the Response to Vitamin D.  
Science 149:184-186. California
- Packett, L. V., and Fordham, J. R. 1965.  
Utilization of Citric Acid by Rumen Microorganisms.  
J. Animal Science 24(2):488-493. Indiana
- Packett, L. V., Plumlee, M. P., Barnes, R. F., and Mott, G. O. 1965.  
Influence of Hemicellulose A and B on Cellulose Digestion, Volatile  
Fatty Acid (VFA) Production and Forage Nutritive Evaluation.  
J. Nutrition 85:89-101. Indiana
- Prescott, J. M., Ragland, Rae S. and Hurley, Ruth J. 1965.  
Utilization of CO<sub>2</sub> and Acetate in Amino Acid Synthesis by Streptococcus  
bovis.  
Proc. Soc. Exptl. Biol. Med. 119:1097-1102. Texas
- Preston, R. L., Schnakenberg, D. D. and Pfander, W. H. 1965.  
Protein Utilization in Ruminants. I. Blood Urea Nitrogen as Affected  
by Protein Intake.  
J. Nutrition 86:281-288. Missouri
- Purser, D. B., Klopfenstein, T. J. and Cline, J. H. 1965.  
Influence of Tylosin and Aureomycin Upon Rumen Metabolism and the  
Microbial Population.  
J. Animal Sci. 24(4):1039-1044. Ohio
- Ramsey, H. A. and Davis, C. L. 1965.  
Metabolism of N-Butyrate by the Adult Goat.  
J. Dairy Sci. 48(3):381-390. Illinois
- Rand, P. G. and Quackenbush, F. W. 1965.  
Cholesterol Levels in the Hypercholesterolemic Rat:Diurnal Variations.  
J. Nutrition 87:485-488. Indiana

- Rand, P. G. and Quackenbush, F. W. 1965.  
Effects of Purified Cis- and Trans- Fatty Acid Derivatives on the  
Hypercholesterolemic Rat.  
J. Nutrition 87:489-492. Indiana
- Rojas, M. A., Dyer, I. A., and Cassatt, W. A. 1965.  
Manganese Deficiency in the Bovine.  
J. Animal Sci. 24(2):664-667. Washington
- Romberg, B. and Benton, D. A. 1965.  
Effect of Type of Carbohydrate on Energy Metabolism and Body Composition  
of Rats Fed Low Protein Diets.  
J. Nutrition 86:289-297. New York
- Sallis, J. D., DeLuca, H. F. and Martin, D. L. 1965.  
Parathyroid Hormone-Dependent Transport of Inorganic Phosphate by Rat  
Liver Mitochondria.  
J. Biol. Chem. 240:2229-2233. Wisconsin
- Schaefer, M. L. and King, K. W. 1965.  
Utilization of Cellulose Oligosaccharides by Cellvibrio gilvus.  
J. Bacteriology 89:113-116. Virginia
- Schumacher, Sister M. F., Williams, M. A. and Lyman, R. L. 1965.  
Effect of High Intakes of Thiamine, Riboflavin and Pyridoxine on  
Reproduction in Rats and Vitamin Requirements of the Offspring.  
J. Nutrition 86:343-349. California
- Seerley, R. W., Emerick, R. J., Embry, L. B. and Olson, O. E. 1965.  
Effect of Nitrate or Nitrite Administered Continuously in Drinking Water  
for Swine and Sheep.  
J. Animal Sci. 24(4):1014-1019. South Dakota
- Smith, R. C. and Salmon, W. D. 1965.  
Effect of Ethionine on the Ribonucleic Acid, Deoxyribonucleic Acid, and  
Protein Content of Escherichia coli.  
J. Bacteriology 89:687-692. Alabama
- Smith, R. C. and Salmon, W. D. 1965.  
Enhancement by Adenine of the Inhibition of Salmonella-Typhimurium by  
Ethionine.  
J. Bacteriology 89:1494-1498. Alabama
- Smith, R. C. and Salmon, W. D. 1965.  
Formation of S-Adenosylethionine by Ethionine-Treated Rats.  
Arch. Biochem. Biophys. 111:191-196. Alabama.
- Snook, J. T. 1965.  
Dietary Regulation of Pancreatic Enzyme Synthesis, Secretion and  
Inactivation in the Rat.  
J. Nutrition 87:297-305. California



- Spahr, S. L., Kesler, E. M. and Flipse, R. J. 1965.  
Utilization of Blood Acetate and Butyrate by the Isolated, Perfused  
Goat Rumen.  
J. Dairy Sci. 48(2):228-233. Pennsylvania
- Stewart, H. F., Ward, G. M. and Johnson, J. E. 1965.  
Availability of Fallout Cs<sup>137</sup> to Dairy Cattle From Different Types of Feed.  
J. Dairy Sci. 48(6):709-713. Colorado
- Stielau, W. J., Freedland, R. A. and Meyer, J. H. 1965.  
Effects of B-Vitamin Deficiencies and of Starvation on Liver Enzyme  
Activities of Growing Rats.  
J. Nutrition 87:109-116. California
- Stallcup, O. T. and Davis, G. V. 1965.  
Assessing the Feeding Value of Forages by Direct and Indirect Methods.  
Ark. Agr. Expt. Sta. Bul. 704. Arkansas
- Tomlin, D. C., Johnson, R. R. and Dehority, B. A. 1965.  
Relationship of Lignification to In Vitro Cellulose Digestibility of  
Grasses and Legume.  
J. Animal Sci. 24(1):161-165. Ohio
- Trupin, J. S. and Broquist, H. P. 1965.  
Saccharopine, and Intermediate of the Amino adipic Acid Pathway of Lysine  
Biosynthesis. I. Studies in Neurospora crassa.  
J. Biol. Chem. 240:2524-2530. Illinois
- Vander Noot, G. W., Cordts, R. H. and Hunt, R. 1965.  
Comparative Nutrient Digestibility of Silages by Cattle and Sheep.  
J. Animal Sci. 24(1):47-50. New Jersey
- Van Dyne, G. M. and Heady, H. F. 1965.  
Interrelations of Botanical and Chemical Dietary Components of Animals  
Grazing Dry Annual Range.  
J. Animal Sci. 24(2):305-312. California
- Vaughan, Sharon T. and Broquist, H. P. 1965.  
Saccharopine Dehydrogenase, a Marker of the Amino adipic Acid (AAA) Pathway  
of Lysine Biosynthesis.  
Fed. Proc. 24:218. Illinois
- Visek, W. J., Dang, H. C., Kirby, S. K. and Sperling, G. A. 1965.  
Growth of Rats Fed Bile Salts Urea and Chlorotetracycline.  
Proc. Soc. Exptl. Biol. Med. 120:48. New York
- Waldrip, W. J. 1965.  
Utilization of Sideoats Grama and Its Value as an Indicator of Grazing  
Intensity.  
J. Range Mgmt. 18(5):277-282. Texas

- Ward, G. M., Stewart, H. F. and Johnson, J. E. 1965. Effects of Feeding Practices on Cs<sup>137</sup> Levels of Milk. J. Dairy Sci. 48(1):38-43 Colorado
- Wessels, J. P. H. and Fisher, H. 1965. Estimation of Protein Reserves and the Nitrogen Content of Organs in Protein-depleted and Repleted Cocks. Brit. J. Nutr. 19(1):57-69. New Jersey
- Whanger, P. D. and Matrone, G. 1965. Effect of Dietary Sulfur Upon the Fatty Acid Production in the Rumen. Biochem. Et. Biophys. Acta. 90: 454-461. N. C.
- Wilken, D. R., Kagawa, T. and Lardy, H. A. 1965. The Role of Adenine Nucleotides in Control of Choline Oxidation by Mitochondria. J. Biol. Chem. 240:1843-1846. Wisconsin
- Wolfe, R. S., Wolin, M. J., Wolin, E. A., Allan, A. M. and Wood, J. M. 1965. Biochemistry of Methane Formation in Methanobacillus omelianskii. In Developments in Industrial Microbiology, Chapter 19, Garmond Pridemark Press, Inc., Baltimore, Md. Illinois
- Wood, J. M., Allan, A. M., Brill, W. J. and Wolfe, R. S. 1965. Formation of Methane From Serine by Extracts of Methanobacillus omelianskii. J. Biol. Chem. 240(12):4564-4569. Illinois
- Wood, J. M. and Wolfe, R. S. 1965. The Formation of CH<sub>4</sub> From N<sup>5</sup> Methyltetrahydrofolate Monoglutamate by Cell-Free Extracts of Methanobacillus omelianskii. Biochem. Biophys. Res. Comm. 19:306-311. Illinois



## AREA NO. 2: BEEF CATTLE -- BREEDING

Problem. Expression of each of the productive and carcass traits of beef cattle varies from breed to breed and between animals within each breed. The beef cattle producer is constantly striving to achieve excellence in one or more of these traits. Frequently his failure to choose the best animals for breeding stock for the most effective mating program results in less than maximum progress. Often the beef cattle producer does not know how to identify, evaluate, and utilize the existing variability to achieve his aim. Research information is needed on heritability of economic traits in beef cattle, genetic and phenotypic correlation between these traits, effectiveness of various selection and breeding programs, and assessment of traits most useful in beef cattle improvement. Basic information on cytology, inheritance of genetic abnormalities and genetic aspects of heritable biochemical and physiological characters will be required for a full understanding of applied problems.

### USDA AND COOPERATIVE PROGRAM

The beef cattle breeding research in the United States has developed as a coordinated program of the USDA and the State experiment stations. It is a continuing program of both applied and basic research carried on by geneticists, animal physiologists, and animal husbandmen. Early efforts in the improvement of beef cattle through performance testing were made by the USDA at Miles City, Mont., and Beltsville, Md. With the advent of regional research, efforts by the State stations were greatly increased and the individual programs were coordinated through regional research projects in three of the important beef cattle producing regions. This joint activity has been and remains characteristic of beef cattle breeding research, and the resulting program is an integrated effort combining to the best advantage the resources of the State experiment stations and the USDA. This report includes both results from Federal and State stations participating in the joint programs.

The regional project in the South is S-10, Improvement of Beef Cattle for the Southern Region Through Breeding Methods. Much of this region is subtropical in climate and in many cases cattle used in other areas are poorly adapted. Environmental conditions adversely affecting survival, reproductive regularity and growth are encountered. Research includes projects at 13 State stations and at the USDA stations at Jeanerette, La.; Front Royal, Va.; and Brooksville, Fla.

In the Western region the beef industry is largely geared to range conditions, with many cattle shipped to areas of abundant grain supply for fattening. Ability to make maximum use of forage available on the range is an important consideration. These problems are studied through regional project W-1, The Improvement of Beef Cattle Through the Application of Breeding Methods.

Research includes projects at 12 State stations and at the USDA station at Miles City, Mont.

Similarly, NC-1, Improvement of Beef Cattle Through Breeding Methods, is geared to problems of the beef industry in the North Central region where beef is produced on farms with pastures of high productivity and ample grain supplies for feedlot finishing. Research includes projects at 12 State stations and at the USDA stations at Fort Robinson, Nebr., and Fort Reno, Okla.

The Federal scientific effort devoted to research in this area totals 12.4 scientific man-years. Of this number 1.3 are devoted to performance testing; 2.8 to genetics and interrelations of performance traits; 1.5 to genetic-environmental interactions; and 6.8 to selection and system of breeding.

#### PROGRAM OF STATE EXPERIMENT STATIONS

The total research effort on beef cattle breeding by State agricultural experiment stations is 49.5 scientific man-years.

#### PROGRESS -- USDA AND COOPERATIVE PROGRAMS

Most beef cattle breeding studies are of a long-term nature and knowledge accumulates slowly due to (1) low reproductive rates with consequent long generation intervals and (2) high maintenance and operational costs per animal (i.e., per genetic unit) which puts limits on animal numbers in most experiments. In the material which follows no attempt has been made to give a progress report on each study but rather to summarize information from specific analyses or summaries made during the year.

##### A. Selection and Systems of Breeding

1. Effectiveness of selection for economically important traits. In a Fort Robinson, Nebr., study with Hereford cattle, selection in three separate herds is (1) solely for weaning weight, (2) solely for 452-day weight, and (3) for an index combining 452-day weight, low fat thickness and a muscling score, respectively. The study was designed with overlapping and repeat use of sires so that in early stages of selection both foundation sires and their selected sons produced progeny in the same years. The selected sons produced progeny that were generally superior to the progeny of their sires. This trend is continuing among progeny of sires selected in subsequent years when compared to progeny of those sires selected in earlier years. (AH dl-51)

At Front Royal, Va., selection for 16 years has been for rate of gain only in one line of Shorthorns and for conformation score only in another. Similar procedures have been followed for shorter periods in the Angus and Hereford breeds. Preliminary summaries indicate that selection for rate of gain has been effective and that an important "spin-off" result has been a higher fertility level in the rate of gain line. (AH dl-48)



2. Crossbreeding. Data on the first phase of the crossbreeding study at the Miles City station have been summarized through the weanling stage. Reproductive data on straightbred Hereford, Angus, and Charolais cows mated to produce both straightbred and crossbred calves showed those mated to produce crossbred gave birth to 4% more calves and weaned 5% more calves, indicating important heterotic effects for fertility and calf survival. The crossbred steer calves were superior to straightbred calves for growth traits. The crossbred steers exceeded the straightbred by 4.4% in birth weight, 3.5% in daily gain to weaning, 4.1% in 205-day weaning, and 2.2% in weaning score. The crossbred heifers exceeded the straightbreds to a lesser extent, the values being 1.5, 1.6, 1.9 and 0.0% for birth weight, daily gain to weaning, 205-day weaning weight, and weaning score, respectively. When bulls of the above three beef breeds were mated to Brown Swiss cows, the Brown Swiss crossbred calves exceeded the average of the straightbred calves of the three breeds by 15.7 lb. in birth weight, 0.29 of a pound per day in gain to weaning, and by 87 lb. in 205-day weaning weight. The substantial advantage of the Brown Swiss crossbred calves at weaning appears to be due to a combination of larger birth weights, higher milk production by the dam, and hybrid vigor resulting from breed crossing. (AH d1-1)

In a Missouri study preliminary estimates of heterosis effects show some hybrid vigor on preweaning traits in crosses among the Angus, Hereford and Charolais breeds. (AH d1-42)

A California study also showed substantial hybrid vigor in fertility, amounting to 16, 18, and 14% more calves born for the Angus x Hereford, Angus x Shorthorn, and Hereford x Shorthorn crosses as compared to the averages of the parental breeds. (AH d1-40)

As reported last year, the first phase of a crossbreeding study with the Angus, Hereford and Shorthorn breeds at Fort Robinson, Nebr., showed economically important hybrid vigor for calf survival, several reproductive characters and for growth to a year of age when all calves were out of straightbred dams.

The second phase of this experiment is now in progress. This involves the evaluation of the effects of hybrid vigor on fertility and mothering ability. That is, straightbred cows of the three breeds are being compared to their crossbred half-sibs when both are bred to the same bulls. For the three years (1963, 1964 and 1965) on which data have been collected, the advantage of the crossbred cow has been 17, 6, and 10%, respectively, for calf crop weaned and 17, 31, and 20 lb., respectively, in average weaning weight of calves at 200 days. Also, there has been a heterosis effect on estimated milk production during early lactation. (AH d1-51)

A Virginia study with the same three breeds also showed important hybrid vigor in crossbred calves out of straightbred cows. This study is also in its second phase comparing productivity of straightbred and crossbred cows. From three calf crops, tentative conclusions are: (1) crossbred cows weaned 2 to 3% more calves than purebred cows, (2) weaning weights of steer calves were

22 lb. in favor of crossbred dams, and weaning weights of heifer calves were 29 lb. in favor of crossbred dams, (3) steer calves from crossbred cows weighed 48 lb. more at time of slaughter and had heavier carcasses by 20 lb. when compared to steers from purebred cows, (4) heifer calves from crossbred cows weighed 29 lb. more at time of slaughter and had heavier carcasses by 18 lb. when compared to heifer calves from purebred cows. Other differences were small. (AH d1-7)

Studies involving Charolais x Hereford and reciprocal crosses compared with their straightbred half-sibs from the parental breeds continue to show a heterosis effect on growth rate. (Ohio)

Charolais, Brown Swiss and Holstein x Hereford topcrosses continue to produce cattle with faster gains than the straightbred Herefords in an Iowa test. Preliminary results show an advantage for the crossbred females in fertility and mothering ability. However, the design of this experiment does not lend itself to an evaluation of the heterosis effects. (AH d1-50)

Comparisons of calf crops from purebred and crossbred cows over a 13-year period in a Louisiana study showed a 7.7% advantage for the crossbreds.

Overall, the results of these studies in several areas of the nation, and involving most of the breeds currently generally available in the United States, show a consistent pattern of heterosis or hybrid vigor. In evaluating the results, it can be concluded that the cumulative effects of heterosis involving many economic traits have considerable economic significance.

3. Inbreeding and linecrossing. Detailed analyses of performance data within inbred lines and from linecrossing studies have, in general, confirmed previous reports indicating reduced productivity with inbreeding and restoration of the losses when crosses are made between lines.

At the Colorado station, linecross Herefords had lower calf death losses than inbreds, with most losses occurring within 60 hours of birth. In yearling bulls, linecrosses were markedly superior to inbreds for estimated breeding soundness, semen quality score, vigor, percent alive and morphology. In cooperation with the University of Illinois, a study of nuclear abnormalities due to disturbances in spermatogenesis was conducted on 80 inbred and linecross Hereford bulls. Significant sire differences were found in the proportions of normal, pyriform, unevenly stained, and diploid sperm nuclei in the semen of their sons. Except for diploid nuclei, which were rare, the linecross sons excelled the inbred sons on the average but differences were non-significant. (AH d1-16)

Detailed analyses on the Miles City linecrossing study, involving five inbred lines, were completed through the weaning stage. The linecross bull and heifer calves exceeded their inbred contemporaries by 3.0 and 3.8% in birth weight, 5.6 and 10.6% in preweaning daily gain, 5.2 and 9.3% in weaning weight, and 2.4 and 2.7% in weaning score. The greater heterosis exhibited by heifer calves is in agreement with results from the Colorado station reported previously. (AH d1-2)



The fourth and last diallel mating of Hereford Lines 1, 2, and 3 were made at the Oregon station. Results from the 1964 calf crop indicate that linecross heifers were superior to inbreds in rate of gain and feed efficiency, whereas there was little difference among bull calves during a postweaning test. The carcass data from the 1964 bulls slaughtered at 1000 lb. showed the linecrosses to grade higher and contain a higher percentage of fat than inbreds. No differences were found between inbred and linecross bulls in spermatozoan morphology. Data on organ weights revealed no differences between inbred and linecross bulls for thyroid, pituitary, adrenal, and heart weights, but testes from linecross bulls were heavier than testes from inbred Hereford bulls. (AH d1-19)

A study on the effects of inbreeding on performance traits was completed at the Havre station during the year. Inbreeding of dam had a slight positive effect on birth weight but a negative effect on weaning weight. Weaning weights of bull calves were depressed more than weights of heifer calves by inbreeding of dam. Bulls having a greater growth potential may be retarded more than heifer calves by lowered maternal abilities associated with increased inbreeding of dam. The partial regression of weaning weight on inbreeding of dam was -1.714 lb. per 1% inbreeding of dam for bull calves, whereas the value for heifer calves was -.145. Inbreeding of calf had no significant influence on the productive traits, but the partial regressions of weaning weight on inbreeding of calf were negative, being -.260 for bull and -.109 for heifer calves. The partial regressions of final-off-feed-test weight on inbreeding of dam and inbreeding of calf were -.413 and -.371 for heifers and -1.434 and -1.347 for bulls, respectively. (Montana)

A summary of six years' data from the same station indicates a substantial advantage for the crossline and topcross steers over rancher steers in daily feedlot gain. Steers from station bulls x rancher cows gained 2.24 lb. per day, whereas steers from rancher bulls x rancher cows gained 2.13 lb. per day. The station crossline steers gained 2.32 lb. per day in the same tests. These results, as well as somewhat similar data from South Dakota, indicate that within-line selection has been effective in improving traits having an appreciable amount of additive genetic variation. (Montana and AH d1-49)

In South Dakota data collected on 860 purebred Hereford calves born in a continuing inbreeding project, initiated in 1952, were used to evaluate the effects of inbreeding on growth and conformation and to evaluate methods of adjusting for inbreeding effects. Two breeding groups each with four sires were established. In one, mating was restricted to four single sire lines, and in the other, mating was restricted to a relationship of less than half-sib. The two groups were formed from the same foundation animals by mating related animals for the foundation of the inbred groups and by mating the same animals in unrelated pairs for foundation of the non-inbred (4 sire) group. In the single sire lines, inbreeding of the calves has reached the 30% level while inbreeding of the dams has reached the 25% level.

Inbreeding effects were studied first by the use of within year-line-sire subclass regressions of trait on inbreeding. Inbreeding of calf and inbreeding of dam effects appeared to be more important on weaning traits than on postweaning traits, although significant linear and quadratic effects of inbreeding were found at both ages. Differential responses by the two sexes appeared in sex main effects and also in several of the interactions involving mating system, sex and environment.

From a practical standpoint the results indicate that breeders could close their herd and initially use as few as four unrelated bulls without suffering severe inbreeding effects for long periods of time. Even in the one-sire lines, inbreeding effects, which were severe at weaning for the females, had partially disappeared by yearling age. Inbreeding appeared to affect conformation even less than growth. (AH dl-49)

## B. Performance Testing

1. Carcass traits and conformation evaluation. A number of analyses have been made in attempts to find indicators in either live animals or carcasses (or both) of carcass components, edible portions of carcasses or retail carcass value. Most of these studies have involved steers of 12 to 18 months of age. Different studies have included animals slaughtered after a time-constant feeding period, slaughtered on weight-constant bases, and slaughtered at estimated-constant finish. In general, weight differences have accounted for 75 to 90% of the variation in carcass value (expressed either as retail sales value or percent edible portion) of animals slaughtered after time-constant feeding periods. Other measurements have been of only limited value in improving predictions made from weights. In animals slaughtered on a weight-constant basis or with adjustments made statistically for weight differences, characteristics such as rib-eye area, fat depth over the rib eye, composition of the 9-10-11 rib cut, ultrasonic estimates of fat thickness in live animals, or certain live-animal estimates and measurements, have some value as indicators of carcass value but are considerably less informative than direct measures of fatness such as carcass fat trim or percent kidney fat. (AH dl-1, AH dl-31, AH dl-49, AH dl-50, AH dl-51, Michigan)

Rib-eye area is not highly accurate in predicting carcass value. It is, however, widely used in industry because of the ease of obtaining it in cattle slaughtered in commercial plants and two square inches per cwt. carcass weight has been rather widely adopted as a standard. Wyoming studies indicate this standard is not uniformly applicable to carcasses of different weights.

Studies comparing the productivity and carcass characters of bulls and steers slaughtered at 18 months of age or less have continued to show important advantages for bulls in rate and efficiency of gain and in carcass leanness. Tenderness of lean has been slightly in favor of steers in most studies. Heifers have been slower gaining and less efficient than either steers or bulls. (AH dl-9, AH dl-32, AH dl-36, AH dl-51, Indiana, Oregon)



In a study of Angus herd classification, results to date are similar to those found in studies with dairy cattle. Weaning weight and grade were correlated with spring and fall classification scores. No correlation was found between weaning grade or weight and the scores given in the spring when the cows were calving. A low negative correlation ( $-.18$ ) was found between weight and the score given in the fall after weaning. (AH d1-31)

2. Growth rates. As discussed in a subsequent section, mature size is an important factor in brood cow efficiency. Means of estimating mature size from weights at young ages would be useful in performance testing programs. An attempt to do this through fitting non-symmetrical logistics curves to calf weights up to one year of age proved not to be very useful for this purpose. Thus, it appears additional studies are needed on the problem. (AH d1-31)

As performance testing of cattle increases among seedstock herds, the problem of between-herd comparisons becomes of increasing importance for persons desiring to purchase tested breeding stock from the most productive herds. In Idaho studies, calves by leased station bulls were brought at weaning into station feedlots from cooperators' herds. Farm differences made up a large percentage of the variation among calves at the beginning of the test but only a minor percentage at the end of the test. Thus, the 140-day test under a common environment was potentially helpful in permitting valid between-herd comparisons for gaining ability.

3. Brood cow productivity. In an extensive study of factors related to cow fertility and weaning weights of their calves, it was found that productivity of cows increased, then tended to level off as cow weight increased. This was true for cow weights at all stages except at the time their calves were weaned. Increased mothering ability is apparently associated with a decrease in cow weight at weaning time. Relationships of cow yearling weight to subsequent productivity were lower than at later ages.

Determining true cow weight is difficult since it is affected by age, parity, and whether or not a cow is nursing or has nursed a calf during the past year or two. However, when statistical adjustments were made for these factors, repeatability of cow weights at various seasons was approximately .70. This indicates that estimates of "true" size are perhaps more realistic than had previously been thought.

Parity classification of the dam had a highly statistically significant effect on the measures of cow productivity. The cows that weaned a calf the previous year weaned 50 lb. more calf in the current year than cows that had been open the previous year or cows that had calved but failed to wean a calf the previous year.

When the measurement data were adjusted for effects of parity of the dam, age of dam, year of calving and, whenever necessary, sex of calf, the following estimates of repeatability were obtained: number of calves born per cow exposed, 0.15; number of calves weaned per cow exposed, 0.16; birth weight, 0.31; average daily gain from birth to weaning, 0.51; 205 day A.W., 0.48;

weaning conformation score, 0.17; weaning condition score, 0.25; and P.T. Index, 0.46. The repeatability estimates obtained in this study, accompanied by the lack of association between cow productivity and yearling weight of the cow, indicate that mild culling of replacement heifers on yearling weight, followed by strict culling on their first records, may be used to increase average weaning weights for a herd. (Ohio)

Transferrin genotypes were not related with fertility nor was there any excess of heterozygous offspring born. Homozygous (Tf AA) and heterozygous (Tf AD) bulls were of similar fertility as measured by calves born per cow exposed. The same was true for the three genotypes (AA, AD and DD) in cows. Transferrin genotype differences were found in measures of cow productivity. Tf AA cows weaned lighter calves which had slower rates of gain and lower adjusted 205-day weights than Tf AD or DD cows. (Ohio)

A study of death losses at birth in purebred Angus and Hereford herds was made at Arkansas. During a 12-year period, 1073 Angus and 904 Hereford calves were born. There was a higher death loss in males than females (4.2 vs. 2.6%) and a higher death loss in Hereford than Angus (5.9 vs. 2.2%). There were slightly higher losses among Hereford cows at all ages up to 10 years but the greatest difference occurred at the first parturitions during which 12.3% of the Herefords and 2.7% of the Angus failed to survive for 24 hours. There was a slight tendency for higher losses earlier in the calving season both during the spring and fall calving seasons. (Arkansas)

4. Maintenance and feed efficiency. As indicated in the previous section, cow productivity increases with weight -- at least up to some optimum point. Production efficiency, however, depends upon productivity in relation to maintenance costs. Knowledge is very incomplete on maintenance requirements of cows of different sizes and degrees of fatness. Some initial studies on the problem are being undertaken. In one study 38 mature, nonpregnant, nonlactating Hereford and Charolais cows were fed at calculated maintenance levels of total digestible nutrients (calculated as  $3/4$  power of body weight) with half at a low and half at a high protein level. Protein level proved to have no effect on body weight changes, thus indicating the low level was adequate for maintenance. Cows varied considerably in weight changes on the calculated maintenance rations, thus suggesting the existence of cow differences in maintenance requirements. There were no significant breed differences but there was a tendency for initially fatter cows to gain or maintain weight while those initially in this condition lost weight. Another trend, probably also related to fatness, was for cows heavy in relation to wither height to gain more or lose less than those lighter in relation to height. (Ohio)

In another study cows were individually fed in drylot throughout life and their calves were raised by them to 240 days of age with creep feed available after 60 days of age. Efficiency of production (E) was estimated by the following formula which assumes that a unit of cow weight is  $4/7$  as valuable as a unit of calf weight:

$$E = \frac{.57 \text{ cow weight} + \text{total weight of calves weaned}}{\text{TDN consumed by cow} + \text{TDN consumed by calves}}$$



Within the weight range of Hereford cows studied (950 to 1350 lb.), the large cows were the most efficient and required less for maintenance per pound of body weight than did small cows.

Cows that were heavier at calving produced less milk but weaned heavier calves. The height at the withers was not associated with milk production but the tall cows tended to wean heavier calves. (AH dl-43)

In a study involving weight, growth rate and feed efficiency of young animals, animals that were initially larger tended to gain faster. Appetite expressed as voluntary feed intake per unit of Metabolic Body Size (feed intake/ $BW^{3/4}$ ) was a major determinant of growth rate ( $r = 0.72$ ) when analyzed on a within ration, within sex basis. Appetite expressed in this fashion was correlated more closely with growth rate than when expressed as intake per 100 pounds body weight. This indicates  $BW^{3/4}$  is a preferable basis for defining energy requirements or intake. Efficiency expressed as pounds live weight gain/energy consumed was closely related to rate of gain ( $r = 0.82$ ,  $P < .01$ ) when analyzed on a within ration, within sex basis. Efficiency (gain/feed consumed) was independent of appetite among all ration groups for steers, and when analyzed by least squares analysis for the bull and heifer group.

Bulls consumed more feed and gained faster than heifers ( $P < .01$ ); however, heifers had significantly larger appetites (feed/ $BW^{3/4}$ ) than bulls.

Appetite, thyroid activity, and growth hormone secretion seem to be the most promising physiological factors for future work. Digestive functions seemed either too constant among animals or too difficult to measure satisfactorily to warrant such future work relating these to animal performance. (Ohio)

### C. Genetics and Interrelationships of Performance Traits

1. Heritability of performance traits. Low heritabilities were obtained by the Colorado station for estimated breeding soundness, semen quality score, vigor, percent alive and morphology in a study on breeding soundness and semen characteristics in Hereford bulls. (AH dl-16)

Preliminary data from the Colorado station dealing with the genetics of serum lipids and their relation to the composition and distribution of fat showed significant sire differences for subcutaneous and intramuscular fat iodine number (measure of saturation) and nonsignificant sire differences for percent rib eye fat. Correlations of subcutaneous fat iodine number and intramuscular fat iodine with percent rib eye fat were low, being 0.22 and -.21, respectively. (AH dl-52)

Heritabilities were estimated for the steers fed as calves, short yearlings, and long yearlings over a 5-year period. A total of 327 Angus and Hereford steers by 49 sires were involved in the study. The evidence suggests that heritabilities are likely to be at least 40 to 50% for average daily gain, feed consumption and feed efficiency. (AH dl-50)

2. Genetic-environmental interactions. The long term genetic-environmental interaction study at Miles City, Mont., and Brooksville, Fla., is becoming fully established. Some general observations at the Miles City location are that the Miles City cows are 175 to 180 lb. heavier than those shipped from Brooksville. Average calving percentages are quite similar for the two groups. Miles City cattle are generally growthier and have weighed more than Brooksville cattle at all ages. At the Brooksville location the Brooksville cattle have exceeded the Miles City cattle in calving rate, calf survival, weaning rate, and weaning weights. Weights at two to three years of age are quite comparable between the two groups. Many of the observed differences to date may be accounted for more by adaptation than true genetic-environmental interactions. (AH d1-41)

3. Genetic defects. Work on the inheritance of heart defects was continued at the New Mexico station. Calves by bulls known to have previously sired calves with a patent ductus arteriosus or a ventricular spetal defect were born alive and apparently normal this year. The same matings were made again this year to determine if these defects are genetically controlled.

The studies of bovine achondroplasia are being continued at the California station. The relationship between the Telemark monster, short-headed dwarf, long-headed dwarf, comprest, compact, Kerry, Dexter, and "bull dog" types are being studied. One intersex bovine was found to be XXY/XX as in the Klinefelter's syndrome in men.

#### PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

##### Selection and Systems of Breeding

Armstrong, J. B., Stonaker, H. H., and Riddle, K. 1965. A study of long-term selection. Colo. Farm and Home Res. 15(4): 8-10. (AH d1-16)

Armstrong, J. B., Stonaker, H. H., Sutherland, T. M., and Riddle, K. R. 1965. Selection and genetic change in inbred Herefords. J. Animal Sci. 24(3): 845. (Abs.) (AH d1-16)

Bogart, Ralph. 1966. The place of crossbreeding in beef cattle. Oreg. Agr. Expt. Sta. Special Report 215. (AH d1-19)

Cundiff, L. V., Bradley, N. W., Kemp, J. D., and Greathouse, T. R. 1966. Performance and carcass characteristics of Hereford and Hereford x Red Poll steers and heifers. J. Animal Sci. 25: 265 (Abs.) (AH d1-51)

DeRouen, T. M., Reynolds, W. L., Temple, R. S., Kincaid, C. M., Meyerhoeffler, D. C., and Warwick, E. J. 1965. Performance of progeny from Angus and Brahman bulls mated to straightbred and Angus-Zebu cross cows. J. Animal Sci. 24: 287. (Abs.) (AH d1-30)



- Christian, L. L., Hauser, E. R., and Chapman, A. D. 1965. Association of preweaning and postweaning traits with weaning weight in cattle. J. Animal Sci. 24: 652-659. (AH dl-50)
- Cole, J. W., Ramsey, C. B., Huff, W. C., Hobbs, C. S., and Temple, R. S. 1966. Effects of three controlled levels of fatness on production, carcass composition, quality and organoleptic qualities of beef steers. J. Animal Sci. 25: 255. (Abs.) (AH dl-9)
- Cundiff, L. V., Willham, R. L., and Pratt, C. A. 1966. Factors to take into account when adjusting weaning weights of calves. Okla. Agr. Expt. Sta. Misc. Publ. 78. (AH dl-31)
- Hicks, Barbara J., and Hazel, L. N. 1966. Predicting retail value of beef carcasses from component parts. J. Animal Sci. 24: 863. (Abs.) (AH dl-50)
- Kyomo, M. L., Stonaker, H. H., Riddle, K., Cramer, D. A. and Richardson, G. 1966. Carcass characteristics of Hereford cows. Am. Soc. Animal Sci. West. Sect. Proc. 17: 163-168. (J. Animal Sci. 25(2): 588 (Abs.)) (AH dl-16)
- Magee, W. T. 1965. Relationship between carcass traits in beef bulls. J. Animal Sci. 24: 851 (Abs.) (AH dl-43)
- Minyard, J. A., and Dinkel, C. A. 1965. Weaning weight of beef calves as affected by age and sex of calf and age of dam. J. Animal Sci. 24: 1067-1071. (AH dl-49)
- Putnam, P. A., Bovard, K. P., Priode, B. M., and Lehmann, R. 1965. Rumen volatile fatty acids and gains of record of performance bulls. J. Animal Sci. 24(1): 166-167. (AH dl-48)
- Ramsey, C. B., Cole, J. W., Temple, R. S., and Hobbs, C. S. 1966. Prediction of separable muscle in carcasses of seven breeds of steers. J. Animal Sci. 25: 256. (Abs.) (AH dl-9)
- Reynolds, W. L., DeRouen, T. M., Meyerhoeffler, D. C., Wiltbank, J. N., and Temple, R. S. 1965. Birth weight and gestation length of beef cattle. J. Animal Sci. 24: 851 (Abs.) (AH dl-30)
- Schalles, R. R., and Marlowe, T. J. 1965. Factors affecting ROP test performance of beef bulls. J. Animal Sci. 24: 851 (Abs.) (AH dl-48)
- Sliger, R. L., Ramsey, C. B., Cole, J. W., and Hobbs, C. S. 1966. The relationships of chronological and physiological age of beef females to carcass and palatability characteristics. J. Animal Sci. 25: 255. (Abs.) (AH dl-9)
- Smith, J. P., and Brown, C. J. 1965. Agonistic behavior and production traits of young beef bulls. J. Animal Sci. 24: 856 (Abs.) (AH dl-9)

- Gaines, J. A., McClure, W. H., Vogt, D. W., Carter, R. C., and Kincaid, C. M. 1966. Heterosis from crosses among British breeds of beef cattle: fertility and calf performance to weaning. J. Animal Sci. 25: 5-13. (AH d1-7)
- Gregory, K. E., Swiger, L. A., Koch, R. M., Sumption, L. J., Ingalls, J. E., Rowden, W. W., and Rothlisberger, J. A. 1966. Heterosis effects on growth rate of beef heifers. J. Animal Sci. 25: 290-298. (AH d1-51)
- Gregory, K. E., Swiger, L. A., Sumption, L. J., Koch, R. M., Ingalls, J. E., Rowden, W. W., and Rothlisberger, J. A. 1966. Heterosis effects on carcass traits of beef steers. J. Animal Sci. 25: 311-322. (AH d1-42)
- Gregory, K. E., Swiger, L. A., Sumption, L. J., Koch, R. M., Ingalls, J. E., Rowden, W. W., and Rothlisberger, J. A. 1966. Heterosis effects on growth rate and feed efficiency of beef steers. J. Animal Sci. 25: 299-310. (AH d1-51)
- Magee, W. T. 1965. How commercial herds change genetically. Quar. Bul. Mich. Agr. Expt. Sta. 48: 4. (AH d1-43)
- McNitt, James I., Stonaker, H. H., and Carroll, E. J. 1966. Breeding soundness in beef bulls. Am. Soc. Animal Sci. West. Sect. Proc. 17: 25-30. (J. Animal Sci. 25(2): 583 (Abs.)) (AH d1-2)
- Reynolds, W. L., DeRouen, T. M., Temple, R. S., and Meyerhoeffler, D. C. 1965. Reproductive performance of Angus and Brahman bulls mated to straightbred and Angus-Zebu cross cows. J. Animal Sci. 24: 287 (Abs.) (AH d1-30)
- Richardson, G. V., Carter, R. C., Gaines, J. A., and Vogt, D. W. 1965. Heterosis in carcass characteristics from breed crossing in beef cattle. J. Animal Sci. 24: 851. (Abs.). (AH d1-7)
- Salisbury, G. W., and Baker, F. N. 1966. Nuclear morphology of spermatozoa from inbred and linecross Hereford bulls. J. Animal Sci. 25(2): 476-479. (AH d1-19)

#### Performance Testing

- Bailey, C. M., Probert, C. L., and Bohman, V. R. 1966. Growth rate, feed utilization, and body composition of young bulls and steers. J. Animal Sci. 25(1): 132-137. (AH d1-36)
- Bailey, C. M., Probert, C. L., Richardson, Paula, Bohman, V. R., and Chancerelle, Julianne. 1966. Quality factors of the longissimus dorsi of young bulls and steers. J. Animal Sci. 25(2): 504-508. (AH d1-36)
- Brown, C. J., Lewis, Jr., P. K., and Heck, M. C. 1966. Evaluating beef carcasses from rib eye area measurement. Ark. Farm Res. 15: 2. (AH d1-9)



Swiger, L. A., Gregory, K. E., Arthaud, V. H., Breidenstein, B. C., Koch, R. M., Sumption, L. J., and Rowden, W. W. 1966. Adjustment factors for carcass, gain and feed traits of beef cattle. J. Animal Sci. 25: 69-72. (AH d1-51)

Vaccaro, Rodolfo, and Dillard, E. U. 1965. Relationship of cow weight changes to calf's growth rate. J. Animal Sci. 24: 857-858. (Abs.) (AH d1-23)

Vitlo, P. D., and Magee, W. T. 1965. Live animal estimates of carcass traits. J. Animal Sci. 24: 853 (Abs.) (AH d1-43)

#### Genetics and Interrelationships of Performance Traits

Bovard, K. P., and Priode, B. M. 1965. Snorter dwarfism in an Angus inbred line. J. Hered. 56: 243-246. (AH d1-48)

Christian, L. L., Hauser, E. R., and Chapman, A. B. 1965. Heritability estimates in beef cattle based on identical and fraternal twin data. J. Animal Sci. 24: 643-651. (AH d1-43)

Minyard, J. A., and Dinkel, C. A. 1965. Heritability and repeatability of weaning weight in beef cattle. J. Animal Sci. 24: 1072-1074. (AH d1-49)

Patton, James D., Crockett, J. R., and Gavan, James A. 1966. Prenatal skeletal development in the bovine. J. Animal Sci. 25: 251 (Abs.) (AH d1-34)

### Related Publications of State Experiment Stations

Andersen, Henry and Plum, Mogens. 1965. Gestation Length and Birth Weight in Cattle and Buffaloes: A Review. J. Dairy Sci. 48(9):1224-1235. Nebraska

Brethour, J. R., Duitsman, W. W. and Smith, W. H. The relationship of feed lot performance of a sire and his progeny. Kansas Agr. Expt. Sta. Bull. 482. April 1965. Kansas

Carroll, F. D. and Rollins, W. C. 1965. Performance of Charbray and Hereford cattle and crosses between them. Animal Prod. 7(1):119-126. California

Cartwright, T. C., Ellis, G. F. Jr., Kruse, W. E. and Crouch, E. K. 1965. Hybrid vigor in Brahman-Hereford crosses. Texas Agr. Expt. Sta., Technical Monograph No. 1. Texas

Christian, L. L., Hauser, E. R. and Chapman, A. B. 1965. Association of Prewaning and Postweaning Traits with Weaning Weight in Cattle. J. Animal Sci. 24(3):652-659. Wisconsin

Christian, L. L., Hauser, E. R. and Chapman, A. B. 1965. Heritability Estimates in Beef Cattle Based on Identical and Fraternal Twin Data. J. Animal Sci. 24(3):643-651. Wisconsin

Cunningham, E. P., and Henderson, C. R. 1965. Estimation of Genetic and Phenotypic Parameters of Weaning Traits in Beef Cattle. J. Animal Sci. 24(1):182-187. New York

Cunningham, E. P., and Henderson, C. R. 1965. Repeatability of Weaning Traits in Beef Cattle. J. Animal Sci. 24(1):188-191. New York

Davenport, R. L., Stonaker, H. H., Riddle, Kent and Sutherland, T. M. 1965. Heritability of Reproductive Performance in Inbred and Line-cross Beef Cows. J. Animal Sci. 24(2):434-437. Colorado



- Dinkel, C. A. and Gregory, K. E. 1965. Evaluation of the Pro-filometer for Detection of Hereford Bulls Heterozygous for the Shorter Dwarf Gene. J. Animal Sci. 24(2):438-440. So. Dak.
- Dinkel, C. A., Wilson, L. L., Tuma, H. J., and Minyard, J. A. 1965. Ratios and Percents as Measures of Carcass Traits. J. Animal Sci. 24(2):425-429. So. Dak.
- Ellis, G. F. Jr., Cartwright, T. C., and Kruse, W. E. 1965. Heterosis for Birth Weight in Brahman-Hereford Crosses. J. Animal Sci. 24(1):93-96. Texas
- Gregory, K. E., Swiger, L. A., Koch, R. M., Sumption, L. J., Rowden, W. W., and Ingalls, J. E. 1965. Heterosis in Preweaning Traits of Beef Cattle. J. Animal Sci. 24(1):21-28. Nebraska
- Marlowe, T. J., Mast, C. C. and Schalles, R. R. 1965. Some Non-genetic Influences on Calf Performance. J. Animal Sci. 24(2):494-501. Virginia
- Marlowe, T. J., and Vogt, D. W. 1965. Heritabilities, Phenotypic Correlations, and Genetic Correlations Involving Pre-weaning Gain and Weaning Grade of Beef Calves. J. Animal Sci. 24(2):502-506. Virginia
- Martin, T. G. and Starkenburg, R. T. 1965. Genetic Correlations Between Beef and Dairy Traits in Dual-Purpose Cattle. World Review of Animal Production 1:45-52. Indiana
- Minyard, J. A. and Dinkel, C. A. 1965. Heritability and Repeatability of Weaning Weight in Beef Cattle. J. Animal Sci. 24(4):1072-1074. South Dakota
- Minyard, J. A. and Dinkel, C. A. 1965. Weaning Weight of Beef Calves as Affected by Age and Sex of Calf and Age of Dam. J. Animal Sci. 24(4):1067-1071. South Dakota
- Putnam, P. A., Bovard, K., Priode, B. M., and Lehmann, R. 1965. Rumen Volatile Fatty Acid and Gains of Record-of-Performance Bulls. J. Animal Sci. 24(1):166-167. Virginia
- Sharrah, Nancy, Kunze, Marion Simone and Pangborn, Rose Marie. 1965. Beef tenderness: Sensory and mechanical evaluation of animals of different breeds. Food Tech. 19:131-136. Calif.
- Smith, Walter H., Wheat, J. D. and Spies, H. G. 1965. Kansas Agricultural Experiment Station Bulletin B-483. Improvement of Beef Cattle Through Breeding Methods. Kansas

Stonaker, H. H. 1965. Goals and methods in beef cattle improvement. Colo. Agr. Expt. Sta. Bul. 523-S. Colorado

Stufflebeam, C. E., Wilson, L. L., Mayer, D. T., Day, B. N., Comfort, J. E. and Lasley. 1965. Seasonal variation in levels of some chemical and hematological components in the blood of Hereford cows. Mo. Agr. Exp. Sta. Res. Bul. 859. Kansas

Swiger, L. A., Gregory, K. E., Sumption, L. J., Breidenstein, B. C., and Arthaud, V. H. 1965. Selection Indexes for Efficiency of Beef Production. J. Animal Sci. 24(2):418-424. Nebraska



### AREA NO. 3: BEEF CATTLE - PHYSIOLOGY

Problem. Reproductive performance is the largest single factor affecting net profit in a cow-calf operation. Increasing the reproductive performance of a beef cow herd will result in more pounds of calf weaned per cow bred. More cows will wean a calf, and more cows will calve early in the calving season when reproductive performance is improved. Poor reproductive performance is largely the result of: (1) cows not showing heat early in the breeding season, (2) cows not conceiving at first service, and (3) calf losses occurring at or near calving. The physiological mechanism responsible for the onset of estrus and conception must be explored further and methods of controlling these adequately must be found if reproductive performance is to be improved.

#### USDA AND COOPERATIVE PROGRAM

The program at present is concerned with methods of altering, improving, or controlling reproductive performance by hormonal and nutritional methods and determining basic information on hormonal relationships during the estrous cycle. The program has approximately 144 cattle involved at Jeanerette, La.; 500 at Fort Robinson, Nebr.; 110 at Miles City, Mont.; 140 at El Reno, Okla.; and 136 at Beltsville, Md. Some reproductive information is also obtained on cattle involved in other studies at all of these locations except Beltsville. Major studies involve: (1) relationship between nutrition and reproductive performance at Miles City, Fort Robinson, El Reno, and Beltsville; (2) hormonal control of the estrous cycle at Fort Robinson; (3) causes of maintenance and regression of the corpus luteum at Fort Robinson; (4) induction of twin ovulations at Miles City; and (5) causes of calf losses at or near calving at Miles City and Fort Robinson.

The Federal scientific effort devoted to this area of work totals 3.3 scientific man-years, all of which are devoted to physiology of reproduction.

#### PROGRAM OF STATE EXPERIMENT STATIONS

The total research effort on physiology of beef cattle by State agricultural experiment stations is 15.3 scientific man-years.

#### PROGRESS -- USDA AND COOPERATIVE PROGRAMS

##### A. Physiology of Reproduction

1. Nutrition and reproduction. In contrast to the 1964 results (Fort Robinson, Nebr.), calving difficulties were not affected by moderate (80 lb.) versus a low (4.3 lb.) levels of TDN during the last 120 days of gestation, but, as previously noted, the interval from parturition to next estrus was

longer (12 days) in cows on low levels of TDN. This did not affect the pregnancy rate during a 60-day breeding period.

There was no apparent benefit from feeding a protein supplement to range cows prior to parturition. However, cows supplemented with grain after parturition returned to estrus sooner and a higher proportion conceived at breeding than did unsupplemented cows. (AH d1-37)

At Jeanerette, La., pregnancy rate was improved when heifers on pasture were supplemented to gain about 150 lb. more than heifers fed less supplement during the yearlong test. (AH d2-34)

Studies conducted at Brooksville, Fla., showed no beneficial effects on calf survival from supplemental vitamin A feeding or injecting to normally managed pregnant beef cows. At Front Royal, Va., the same treatments resulted in a 4.3% reduced mortality among calves born alive. (AH d3-2, AH d1-48)

Supplemental range feeding did not prove to be beneficial presumably because an optimum supply of nutrients were available from the 1965 lush range forage at Miles City, Mont. However, the 2.85 lb. average daily weight loss during the 30-day period following calving was considered important and indicative of a critical period in postpartum nutrition. (AH d3-1)

2. Losses at or near calving. At Miles City, Mont., 70% of the calf losses during the last four years occurred at or shortly after birth. The most frequent cause of death was delayed or difficult parturition. (AH d1-33, AH d1-37)

3. Puberty. Preliminary data on age at puberty show no advantage for crossbred bulls at Miles City, Mont. (AH d1-33)

4. Control of estrus. Attempts at Fort Robinson, Nebr., to control estrus by a single injection of a progestogen and an estrogen were unsuccessful. Synchronization of ovulation (oral and injection) following estrus synchronization was plagued by incomplete inhibition of estrus. However, when estrus was controlled, a breeding trial using a time constant insemination procedure resulted in 52% of the heifers becoming pregnant. (AH d1-37)

Observations at Miles City, Mont., on the lack of effect of local steroid administration on ovarian activity tend to support the hypothesis that systemically injected compounds act on the pituitary either directly or via the hypothalamus rather than directly on the ovary. (AH d1-33)

5. Fertility data from breeding herds. Data from Fort Robinson, Jeanerette and Miles City continue to indicate that reproductive efficiency is increased in crossbred cows. (AH d1-6, AH d1-33, AH d1-37, AH d1-30)



PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Reynolds, W. L., DeRouen, T. M., Temple, R. S., and Meyerhoeffer, D. C.  
1966. Reproductive traits of Angus, Zebu and Zebu-cross cows.  
J. Animal Sci., 25:252 (Abs.) (AH d1-30)

Selected Publications of State Experiment Stations

Hurst, Victor, Kelley, J. W., Godley, W. C., Hill, J. R., Jr.,  
Powell, H. S. and Roebuck, D. E. 1965. Infertility in Beef Cattle.  
South Carolina Agr. Expt. Sta. Tech. Bul. 1020 S.Car.

Niswender, G. D., Kaltenbach, C. C., Shumway, R. P., Wiltbank, J. N.  
and Zimmerman, D. R. 1965. Alteration of Ovarian Activity in  
Cycling Beef Heifers with Small Daily Injections of Estradiol.  
J. Anim. Sci. 24:986 Nebr.

Plasse, D., Koger, M. and Warnick, A. C. 1965. Length of Calving  
Interval and Time of Conception in Relation to Calving and the Beginning  
of the Service Period in Four Brahman Cattle Ranch Herds in Florida.  
Zentralblatt fur Veterinarmedizin Reihe A, Band 12, Heft 3. S. 250-262 Fla.

Plasse, D., Warnick, A. C. and Koger, M. 1965. Alter bei Gesch  
Lechtsreife und Jahreszeitliche Abhangigkeit der Ovulationsrate von  
Brahman- und Kreuzungsfarsen in Florida. Zeitschrift fur Tierzuchtung und  
Zuchtungsbiologie Band 81, Heft 3S. 231-240 Fla.

Stufflebeam, C. E., Wilson, L. L., Mayer, D. T., Day, B. N., Comfort, J.E.  
and Lasley, J. F. 1965. Seasonal Variation in Levels of Some Chemical  
and Hematological Components in the Blood of Hereford Cows. Missouri  
Agr. Exp. Sta. Res. Bul. 859 Mo.

Wiltbank, J. N., Zimmerman, D. R., Ingalls, J.E. and Rowden, W. W. 1965.  
Use of Progestational Compounds Alone or in Combination with Estrogen  
for Synchronization of Estrus. J. Anim. Sci. 24:990 Nebr.

Wolf, F. R., Almquist, J. O. and Hale, E. B. 1965. Prepuberal Behavior  
and Puberal Characteristics of Beef Bulls on High Nutrient Allowance.  
J. Anim. Sci. 24:761-765 Penn.

#### AREA NO. 4: BEEF CATTLE -- NUTRITION AND MANAGEMENT

Problem. Producers of beef cattle need improved feeding methods which will result in optimum pasture and feedlot gains, reduced feed consumption per pound of beef produced, optimum reproductive rates, and desired carcass qualities. To meet these needs basic nutritional information is required such as: When should beef animals be fed for maximum gains and when for more limited gains? What nutrient combinations produce rapid growth of muscle with a minimum of fat deposition? How may breeding animals be economically raised that will be capable of a high level of reproductive performance over a long lifetime? What are the nutritive contributions made by range and pasture and what supplementation is required when each is used? Research is also needed on the relationship between animal production and type of shelters and equipment, feeding systems, and methods of increasing labor efficiency.

#### USDA AND COOPERATIVE PROGRAM

This is a continuing program carried on by nutritionists, biochemists, and animal husbandmen on basic and applied problems related to feeding and management of cattle for beef. The work is in progress (1) at Beltsville, Md.; (2) in cooperation with State experiment stations at federally owned stations in Miles City, Mont.; Crawford, Nebr.; El Reno, Okla.; Jeanerette, La.; Brooksville, Fla.; Front Royal, Va.; Newell, S. Dak.; and (3) in cooperation with State experiment stations at Tifton, Ga.; and College Station, Tex.

There are contracts totaling \$251,754 with the California, Kentucky, Florida, Wisconsin, and Nebraska Agricultural Experiment Stations. These projects are concerned with the methods of feed preparation and level of grain in the ration, the sites and amount of starch utilization in the ruminant digestive tract, ration components which control feed intake, graded levels of energy intake upon reproductive performance in beef cattle and management of males of beef and dairy breeding for beef production. These projects are for either 3 or 4 years (1964-1967 or 1968), and their basic purpose is to determine the potential for increased utilization of grains for beef production.

There is one grant involving Public Law 480 funds with the Agricultural College in Poznan, Poland. The project is to determine the trace mineral content of forages as affected by stage of growth and methods of harvesting and storing. The project is for a five-year period (1963-1968) and is supported by \$47,311.66 equivalent in Polish zlotys. Another grant with the Institute of Biochemistry and Biophysics in Warsaw, Poland, is to determine the metabolic pathway of protein biosynthesis on the liver microsomes of the guinea pig. The project is for five years (1963-1968) and is supported by \$60,411.46 equivalent in Polish zlotys.



The Federal scientific effort devoted to research in this area totals 9.8 scientific man-years. Of this number 4.6 are devoted to digestion and metabolism; 0.4 to concentrates; 0.7 to forage preservation and utilization; 1.1 to nutrient requirements; 1.9 to range and pasture management; 0.6 to management practices; and 0.5 to behavior.

#### PROGRAM OF STATE EXPERIMENT STATIONS

The total research effort on beef cattle nutrition and management by State agricultural experiment stations is 104.2 scientific man-years.

#### PROGRESS -- USDA AND COOPERATIVE PROGRAMS

##### A. Digestion and Metabolism

1. Digestion and balance studies. When comparing all-concentrate rations based upon corn, wheat, barley, or milo, digestibility of the dry matter and nitrogen retention were significantly less when steers consumed the milo ration. Steer plasma amino acids varied significantly with the grain being fed. (AH d2-37)

Apparent digestible dry matter or energy were not affected by replacing 5% molasses with 5% soy oil or the presence of 1.5% urea in a cattle ration containing over 90% cracked corn. (AH d2-37)

Ruminal ammonia, digestibility, nitrogen retention, and plasma amino acids are being determined in a metabolism trial with steers fed uric acid, urea phosphate, biuret, or urea as the sole source of dietary nitrogen. Preliminary information suggests that, when compared to urea, uric acid is degraded at a moderate rate and biuret is degraded very slowly to ammonia in the rumen. Such information is valuable in determining the combination(s) of non-protein nitrogen sources for most efficient nitrogen and feed utilization. (AH d2-37)

In other purified diet studies, nitrogen retention was greater when isolated soy protein, rather than urea, supplied all of the dietary nitrogen. Serine and glycine were detected in greater quantities while valine, isoleucine, leucine and phenylalanine were detected in lesser quantities in the blood plasma when steers were fed the urea diet. A lack of sufficient quantities of ruminal branched-chain VFA may have been responsible for the low plasma levels of valine, isoleucine and leucine. (AH d2-37)

2. Salivary secretion. Total, mixed salivary secretion was less when steers consumed an all-concentrate ration based on milo (1.1 liters/hr.) rather than corn (1.6 liters/hr.). Total ruminal dry matter content was less when steers were fed the corn ration than when they were fed wheat or milo rations. (AH d2-37)

Preliminary results suggest that high ruminal ammonia concentrations and/or high ruminal pH tend to depress the rate of salivary flow. Conversely

rapidly fermentable rations (N-free) and/or low ruminal pH tend to stimulate salivary flow. (AH d2-37)

Trials are in progress to determine if there is an interaction between the physical form of the ration (pelleted vs. ground) and the level of intake as they affect rate of salivary secretion by steers. Other physiological measures include EKG, respiration and heart rates, blood pressure, and ruminal metabolite concentrations. (AH d2-37)

3. Metabolic diseases. On the basis of the reduction in calculi, gain, and feed efficiency, the following ranking in overall effectiveness has been made of the various chemical compounds tested at College Station, Texas: ammonium chloride, 100; potassium bicarbonate and calcium carbonate (sheep only), 75; diammonium phosphate, sodium carbonate, potassium carbonate, sodium bicarbonate and potassium chloride, 50; sodium chloride and phytic acid, 25; and magnesium oxide, disodium phosphate and dipotassium phosphate, no effect or an increase in calculi. There is some indication that a portion of the ammonia in the ammonium chloride may be utilized as a source of dietary nitrogen. Ammonium chloride and diammonium phosphate were added to the diet at about one-half the level of the other materials tested. (AH d2-31)

In grass tetany studies at Newell, S. Dakota, magnesium and calcium supplements for cows on spring pasture increased blood magnesium and calcium concentrations. Supplemental protein had no effect. (AH d2-35)

4. Pesticide residues. Average DDT residues in muscle samples from cattle administered DDT via the rumen was 26 ppm. as compared to 349 ppm. in fat depots. When the residue was expressed on an extractable fat basis, the muscle extract contained about 6% more residue. DDT residue concentrations in the caudal, cod, ruffle, caul, external rib, internal rib, brisket, heart, and kidney fat; and rib eye, round, diaphragm muscle, and psoas major were found to vary considerably (296 ppm. to 552 ppm.). However, there was no consistency in concentration by location among animals.

The residue concentration in the caudal fat appears to approximate the average concentration among the locations sampled. The average molar percentages of DDT, DDD and DDE in the muscle and blood were about 56, 29 and 15, respectively. The same molar percentages for milk were 81, 11, and 8. Values for fat depots were intermediate (67, 25, and 8). Cattle receiving 300 mg. DDT/kg. body weight over a three-day period as compared to cattle receiving the same dose over a 30-day period reached higher peak concentrations at all sampling sites but also apparently eliminated the residues more rapidly. Lactating cows tended to have lower residue levels presumably because of the residues excreted in the milk. (AH d2-44)

Recent observations at Front Royal confirm earlier results which indicate that properly supplemented apple pomace may be used as a feed for wintering pregnant beef cows but the level of DDT in the pomace should be determined so that it may be diluted if necessary. (AH d2-43)



Preliminary results indicate that feeding p, p<sup>1</sup>-DDT in a concentrate or roughage type diet has no effect upon rumen fermentation, EKG, heart rate, respiration patterns, and blood pressure. However, ruminal fluid was found to contain more DDD than DDT suggesting a dechlorination of the DDT molecule in the rumen. (AH d2-44)

In experiments with fattening steers fed heptachlor contaminated rations, fat biopsy samples contained .60 and .73 ppm. after a six-month feeding period on moderate and moderately highly contaminated rations, respectively. During the succeeding three months, they continued to increase (plus .32 ppm.) among steers still receiving the contaminated ration. Increases were also noted among steers fed rations free of heptachlor. These increases were least (plus .14 ppm.) for steers fed ad libitum and with the largest weight gains; intermediate (plus .22 ppm.) for steers fed the same ration ad libitum but with protomone, and with intermediate weight gains; and largest (plus .45 ppm.) for the limited fed steers with the smallest weight gains. It is presumed that dilution effects are involved.

MC-A-600 was used in feeding tests at Tifton, Ga., but the analyses are not completed. (AH d2-32)

5. Microbiology. A mixed microbial population, supplied alfalfa meal in an "artificial rumen" continuous culture maintained at pH 5.0 and 5.5, developed more like bacteria usually found in the rumens of animals fed high-concentrate diets ad libitum than those fed roughage. Anaerobic Lactobacillus and Selenamonus Ruminatium were predominant among the bacterial strains isolated. (AH d2-26)

Bacterial strains isolated from steers fed non-protein nitrogen (urea) purified diets contained a high proportion of bacteria that produced a final pH below 5. (AH d2-26)

## B. Nutrient Requirements

1. Growth and Reproduction. Daily gains for calves, raised on purified diets containing all of the nitrogen from urea or isolated soy protein, were compared to gains by calves fed a natural diet. Calves were weaned at 83 days of age. Pounds daily gain for bulls from 14 to 84 days of age and from 84 to 210, respectively, were: urea, 0.8, 1.0; isolated soy, 1.0, 1.7. Gains by heifers during these same time intervals were: urea, 0.7, 0.5; isolated soy, 0.9, 1.0; natural, 0.8, 1.6.

Semen characteristics are being studied in cooperation with Swine Physiology Investigations. Semen data indicate that puberty was attained at 43 weeks by bulls fed isolated soy and 54 weeks by bulls fed urea. (AH d2-37)

Rations containing none, 1/2, 2/3 of the total protein equivalent as urea are being fed to beef females in a long-term reproduction study. Gains and reproductive performance have been nearly the same for each treatment group. The cows are now calving for the first time. (AH d2-22)

Studies on protein synthesis are now being concentrated on the occurrence of peptides which may be connected with nucleotides and on the isolation of such peptide material from animal tissue. (E21-AH-7)

#### C. Concentrates

1. High concentrate rations for finishing cattle. In a 126-day feeding trial, steer and heifer gains were again depressed when 5% soy oil (2.2 vs. 1.6 lb./day) replaced molasses in a ration containing more than 90% cracked corn. Ruminal ammonia concentrations (13 vs. 10 mg./100 ml.) and feed intake (17 vs. 14 lb./day) were also decreased when cattle were fed the oil ration. As expected, the steers outgained the heifers (2.1 vs. 1.7 lb./day). (AH d2-37)

Current results of a study of cereal grain utilization by steers at Davis, Calif., (112 days on feed) as affected by method of preparation show no trends as a result of steaming barley, corn, milo or wheat for 8 minutes, 0 psi; 1.5 minutes, 20 psi; 1.5 minutes, 60 psi; or 20 minutes, 0 psi. (AH d2-38)

Yearling steers at Tifton, Ga., gained more on a 90% grain ration (2.9 lb./day) than on a 60% grain ration (2.4 lb./day). As reported previously, full-fed steers performed better than restricted-fed (95% or 90%) steers. In another study, yearling steers and steer calves were found to efficiently utilize rations in which most or all of the supplemental nitrogen comes from urea.

At El Reno, Okla., in a group feeding trial with milo rations, replacement of 25% or 50% of the natural protein supplement with urea caused no decrease in feed intake, gain, or carcass grade. Replacement at 75% caused decreases in feed intake, gain, and carcass grade. In the same trial, little difference in the average feeding value of cottonseed meal and fish meal was noted. (AH d2-37)

In vitro studies at Kentucky indicate that aspartic acid is more effective than other amino acids tested, as a nitrogen source for starch digestion. However, none were as effective as urea nitrogen. (AH d2-39)

#### D. Forage Preservation and Utilization

Steers fed pelleted coastal bermudagrass that was dehydrated, partially field cured or fully field cured, gained 1.70, 1.73, and 1.35 pounds per day, respectively, in a series of feeding trials at Tifton, Ga. (AH d2-42)

Also see saliva study, Section A, 2.

#### E. Range and Pasture Management

Range management studies at Miles City, Mont., indicate that the use of seeded, high-producing, introduced grass and alfalfa supplemental spring



pastures significantly improve fertility and productivity of breeding cows on native range. It is estimated that the investment in seeded spring pastures has been returned in less than three years. (AH d3-1)

Calves on low-preweaning nutritional levels at Fort Reno, Okla., exhibited compensatory gains when put in the feedlot, and were more efficient converters of feed. However, calves on a high pre-weaning nutritional level required less time to reach market weight and had a lower percent of carcass fat. (AH d3-7)

At Brooksville, Fla., liver vitamin A values for calves from vitamin A treated dams were much higher than for calves from untreated dams, but performance was not affected. (AH d3-2)

At Fort Reno, Okla., results of switching cows from a very high nutritional level during wintering to a moderate nutritional level, indicate that the damage to milk producing ability occurs early in life and is not corrected by switching to lower levels after the third winter. (AH d2-36)

#### F. Management Practices

Steers were fed grass, sorghum and corn silages alone, with molasses ad libitum, or with corn-milo grain at Jeanerette, La. Steers consumed more grass and sorghum silage but gained less than steers fed corn silage. Gains were similar when steers were fed molasses or corn-milo in addition to silage. Results from a subsequent study on the effect of number of steers per lot suggests that crowding of animals may reduce average daily gains and feed efficiency. (AH d2-34)

Studies at Tifton, Ga., indicated little difference in performance of cows and calves when wintered on coastal bermudagrass hay supplemented with two levels of cottonseed meal, a small amount of corn and cottonseed meal or an hour's grazing of small grain pastures. (AH d2-42)

The trace element study of soils and forages in Poland indicate that there was not a distinct influence of vegetative stage on the levels of copper, cobalt, iron, and manganese. Only zinc content appeared to fall with the growth of the plants. (E21-AH 6)

Steers on studies designed to identify and define factors associated with meat quality as affected by maturity and nutritional levels (high, limited: high and limited) are averaging 1.85, 1.75, and 1.2 after 480 days on test.

Injecting calves with iron-dextran (26 mg. iron) at 60 days of age had little influence on calf weaning weight in studies at Newell, S. Dakota. The use of injectable iron-dextran is not recommended. (AH d2-35)

#### G. Behavior

1. Feeding. There were no apparent differences in feeding patterns among steers fed all-concentrate corn or wheat rations. Time at the feeder averaged 92 minutes daily, which is about one-half the time spent at the feeder when a 75% concentrate ration is fed.

Irrespective of time of day or sex (heifers vs. steers), major feeding intervals occurred during the last three hours of light when pens were artificially lighted for 12 hours and dark for 12 hours. The values for steers and heifers were nearly identical, with 59% of the time at the feeder occurring during the lighted intervals.

Adaptation to a reversal of the light:dark intervals occurred within three weeks. Our observation on the effects of light on cattle feeding behavior are gathered during the fourth week on an experimental regime.

Preliminary results from a cafeteria cattle feeding behavior study indicate a preference for a coarsely ground 25% roughage ration, over the same ration as a pellet, or an 89% roughage ration pelleted or ground. The preference was more obvious in this study (when all feeds were available at the same time) than when the rations were offered one at a time.

2. Social. A series of studies were conducted to determine the occurrence and strength of a social relationship between steers and sheep when kept together in drylot and pasture. It was found that in a pair that was kept together for about four years, a social relationship developed to such an extent that it was not weakened by the introduction of animals from either or both species.

At Gainesville, Fla., several studies were completed using fistulated steers to establish experimental procedures and to measure effects of sampling and level of concentrate intake on the use of materials to control supplementary feed intake. Certain types and levels of fats and oils in combination with salt show promise as a means of controlling supplemental feed intake.  
(AH d2-40(c))



PUBLICATIONS - USDA AND COOPERATIVE PROGRAMS

Digestion and Metabolism

- Bond, J. and Putnam, P. A. 1965. Nutritive value of sweet potato trimmings fed to beef steers. J. Animal Sci., 24: 1216. (Abs.) (AH d2-37)
- Crookshank, H. R., Packett, L. V., Jr., and Kunkel, H. O. 1965. Ovine urinary calculi and pelleted rations. J. Animal Sci., 24: 638. (AH d2-31)
- Oltjen, R. R., Gutierrez, J., Lehmann, R. P., and Davis, R. E. 1966. Rumen chemical and microbial characteristics of steers fed a purified and a natural diet. J. Animal Sci., 25: 521. (AH d2-37)
- Oltjen, R. R., Putnam, P. A. and Davis, R. E. 1965. Wheat vs. corn in all-concentrate steer rations. J. Animal Sci., 24: 899. (Abs.) (AH d2-37)
- Oltjen, R. R., Putnam, P. A., and Davis, R. E. 1965. Salivary and metabolic studies with steers fed pelleted or unpelleted conventional and purified rations. J. Animal Sci., 24: 1126. (AH d2-37)
- Oltjen, R. R., Putnam, P. A. and Davis, R. E. 1965. Salivary study: urea vs. isolated soy protein in purified diets for steers. J. Animal Sci., 24: 1218. (Abs.) (AH d2-37)
- Putnam, P. A. and Davis, R. E. 1965. Postruminal fiber digestibility. J. Animal Sci., 24: 826. (AH d2-37)
- Putnam, P. A., Lehmann, R. and Davis, R. E. 1965. Feed intake and salivary secretion by steers. J. Animal Sci., 24: 900. (Abs.) (AH d2-37)
- Putnam, P. A., Yarns, D. A., and Davis, R. E. 1965. Ration effects on salivary secretion by steers. J. Animal Sci., 24: 1216. (Abs.) (AH d2-37)
- Slyter, L. L., Blank, F. C., and Putnam, P. A. 1966. Microbial changes associated with decreased pH in a continuous culture artificial rumen. Federation Proc., 25: 544. (Abs.) (AH d2-37)
- Slyter, L. L., Oltjen, R. R., and Putnam, P. A. 1965. Rumen microorganisms in wheat vs. corn all-concentrate steer rations. J. Animal Sci., 24: 1218. (Abs.) (AH d2-37)
- Yarns, D. A., Putnam, P. A., and Leffel, E. C. 1965. Rumen constituents affecting salivary secretion. J. Animal Sci., 24: 805. (AH d2-37)

### Concentrates

- Totusek, R., Renbarger, R. E., Hall, G. A. B., and Tillman, A. D. 1966. The value of cottonseed meal, fish meal and urea in milo rations for fattening calves. Okla. Agr. Expt. Sta. Misc. Publ. 78. (AH d2-37)
- Hall, G. A. B., Absher, C. A., Totusek, R., and Tillman, A. D. 1966. The net energy of milo and corn for cattle. J. Animal Sci., 25: 249. (Abs.) (AH d2-37)

### Management

- Stuedemann, J. A., Ewing, S. A., Guenther, J. J., and Odell, G. V. 1966. Effect of pre-weaning plane of nutrition on growth and development of beef calves. Okla. Agr. Expt. Sta. Misc. Publ. 78. (AH d3-7)
- Smithson, L., Ewing, S. A., Pope, L. S., and Stephens, D. F. 1966. The cumulative influence of level of wintering on the lifetime performance of beef females. Okla. Agr. Expt. Sta. Misc. Publ. 78. (AH d2-36)
- Ewing, S. A., Smithson, L., Stephens, D. F., and McNutt, D. 1966. Weight loss patterns of beef cows at calving. Okla. Agr. Expt. Sta. Misc. Publ. 78. (AH d2-36)

### Behavior

- Putnam, P. A., Lehmann, R., and Davis, R. E. 1965. Light and heifer feeding behavior. J. Animal Sci., 24: 900. (Abs.) (AH d2-37)
- Putnam, P. A., Lehmann, R., and Davis, R. E. 1965. Effect of electric lighting on drylot feeding behavior of cattle. Conference Proc., Electromagnetic radiation in Agriculture, p. 16. (AH d2-37)



Related Publications of State Experiment Stations

Beardsley, D. W., McCormick, W. C., and Southwell, B. L. May 1965.  
Ground Snapped Corn in High Concentrate Rations for Fattening Steers.  
Ga. Agr. Exp. Sta. Bul. (N.S.) 136. Georgia

Bryant, H. T., Hammes, R. C. Jr., Blaser, R. E. and Fontenot, J. P. 1965.  
Effects of Feeding Grain to Grazing Steers to be Fattened in Drylot.  
J. Animal Sci. 24(2):676-680. Virginia

Bull, L. S., Bush, L. J., Friend, J. D., Harris, B. Jr. and Jones, E. W.  
1965.  
Incidence of Ruminal Parakeratosis in Calves Fed Different Rations and  
Its Relation to Volatile Fatty Acid Absorption.  
J. Dairy Sci. 48(11):1459-1466. Oklahoma

Buric, J. and Foster, J. E. 1965.  
Comparison of Morea Versus Soybean Oil Meal as a Supplement for Finishing  
Beef Heifer Calves.  
Univ. Md. Exp. Sta. Bul. 475. Maryland

Cabezas, M. T., Hentges, J. F. Jr., Moore, J. E. and Olson, J. A. 1965.  
Effect of Diet on Fatty Acid Composition of Body Fat in Steers.  
J. Animal Sci. 24(1):57-61. Florida

Cullison, A. E. and Ward, C. S. 1965.  
Coastal Bermudagrass Hay as a Source of Vitamin A for Beef Cattle.  
J. Animal Sci. 24(4):969-972. Georgia

Edwards, R. L., Godley, W. C., Skelley, G. C., Moore, S. L., Rauton, R. M.,  
Ritchie, R. R., Williams, W. P., Wheeler, H. O., Borgman, R. F. and  
Brock, D. 1965. South Carolina  
The Use of Vitamin A in Three Drylot Finishing Rations for Steers.  
Anim. Sci. Res. Series 14, S. C. Agr. Exp. Sta., Clemson Univ.

Fontenot, J. P. and Blaser, R. E. 1965.  
Symposium on Factors Influencing the Voluntary Intake of Herbage by  
Ruminants. Selection and Intake by Grazing Animals.  
J. Animal Sci. 24(4):1202-1208. Virginia

Garrett, W. N. 1965.  
Comparative Feeding Value of Steam-Rolled or Ground Barley and Milo  
for Feedlot Cattle.  
J. Animal Science 24:726-729. California

Garrett, W. N. and Worker, G. F. Jr. 1965.  
Comparative Feeding Value of Silage Made From Sweet and Dual Purpose  
Varieties of Sorghum.  
J. Animal Sci. 24(3):782-785. California

- Guenther, J. J., Bushman, D. H., Pope, L. S. and Morrison, R. D. 1965.  
Growth and Development of the Major Carcass Tissues in Beef Calves  
From Weaning to Slaughter Weight, With Reference to the Effect of Plane  
of Nutrition.  
J. Animal Sci. 24(4):1184-1191. Oklahoma
- Haines, C. E., Chapman, H. L., Kidder, R. W. and Greene, R. E. L.  
July 1965.  
Effects of Feeding Limited Amounts of Concentrate to Stocker Steers on  
Pasture.  
Fla. Agr. Exp. Sta. Bul. 693. Florida
- Harbers, L. H., Tillman, A. D., Vissek, W. J., and Glimp, H. A. 1965.  
Some Effects of Jackbean Urease Immunity in Young Calves.  
J. Animal Science 24(1):102-104. Oklahoma
- Hawkins, G. E., Autrey, K. M. and Huff, J. W. 1965.  
Effect of Partial Deprivation of Parotid Saliva on Physiological Responses  
of Steers Fed Three Levels of Dietary Sodium.  
J. Dairy Sci. 48(12):1663-1667. Alabama
- Heinemann, W. W. 1965.  
Digestibility and Feeding Value of Cottonseed Meal and Nonprotein  
Nitrogen Compounds for Beef Cattle.  
Wash. Agr. Exp. Sta. Bul. 666. Washington
- High, T. W., Chapman, E. J., Whittenberg, B. L. and High, J. W. 1965.  
Fescue Pastures, Under Different Management Systems, and Orchardgrass-  
Clover for Yearling Slaughter Steer Production.  
Tenn. Agr. Exp. Sta. Bul. 385. Tennessee
- High, T. W., Duncan, H. R., Felts, J. H. and High, J. W. Feb. 1965.  
Producing Yearling Steers on Irrigated Bluegrass-Clover and Orchardgrass-  
Clover Pastures.  
Tenn. Agr. Exp. Sta. Bul. 387. Tennessee
- High, J. W., Safley, L. M., Long, O. H., Duncan, H. R. and High, T. W.  
1965.  
Combinations of Orchardgrass, Fescue, and Ladino Clover Pastures for  
Producing Yearling Steers.  
Tenn. Agr. Exp. Sta. Bul. 388. Tennessee
- Hobbs, C. S., High, T. W., Jr., and Dyer, I. 1965.  
Orchardgrass and Fescue Pastures for Producing Yearling Slaughter Steers.  
Tenn. Agr. Exp. Sta. Bul. 386. Tennessee
- Hull, J. L., Meyer, J. H., Bonilla, S. E. and Weitkamp, W. 1965.  
Further Studies on the Influence of Stocking Rate on Animal and Forage  
Production From Irrigated Pasture.  
J. Animal Sci. 24(3):697-704. California



- Klosterman, E. W., Althouse, P. G. and Cahill, V. R. 1965.  
Effect of Corn Silage or Ground Ear Corn Full Fed at Various Stages of  
Growth and Fattening Upon Carcass Composition of Beef Cattle.  
J. Animal Sci. 24(2):454-458. Ohio
- Lofgreen, G. P. 1965.  
Net Energy of Fat and Molasses for Beef Heifers With Observations on the  
Method for Net Energy Determination.  
J. Animal Sci. 24(2):480-487. California
- McCormick, W. C., Beardsley, D. W. and Southwell, B. L. Apr. 1965.  
Coastal Bermudagrass Pellets for Fattening Beef Steers.  
Ga. Agr. Exp. Sta. Bul. (N.S.) 132. Georgia
- Meiske, J. C., Prouty, R. M., Schuman, L. M. and Scaletti, J. V. 1965.  
Effect of Sodium Bisulfite Additions to Corn Silages.  
J. Animal Sci. 24(2):705-710. Minnesota
- Meyer, J. H., Hull, J. L., Weitkamp, W. H. and Bonilla, S. E. 1965.  
Compensatory Growth Responses of Fattening Steers Following Various Low  
Energy Intake Regimes on Hay or Irrigated Pasture.  
J. Animal Sci. 24(1):29-37. California
- O'Donovan, J. P., Plumlee, M. P., Smith, W. A. and Beeson, W. M. 1965.  
Availability of Phosphorus in Dicalcium Phosphates and Defluorinated  
Phosphates for Steers.  
J. Animal Sci. 24(4):981-985. Indiana
- Rice, R. W. and Paules, L. H. 1965.  
Comparison of a Fifty Per Cent Hay and No-Hay Ration With or Without  
Supplemental Vitamin A for Beef Production From Young Dairy Calves.  
J. Dairy Sci. 48(12):1668-1671. Wyoming
- Southwell, B. L. and Hughes, R. H. March 1965.  
Beef Cattle Management Practices for Wiregrasspine Ranges of Georgia.  
Ga. Agr. Exp. Sta. Bul. (N.S.) 129. Georgia
- Stone, P. A. and Fontenot, J. P. 1965.  
Effect of Available Energy Level of Fattening Rations on Utilization of  
Nitrogen and Digestibility by Steers.  
J. Animal Sci. 24(3):757-760. Virginia
- Thompson, J. T., Bradley, N. W. and Little, C. O. 1965.  
Ruminal Volatile Fatty Acid Concentrations and Performance of Steers Fed  
Different Levels and Forms of Hay and Grain.  
J. Animal Sci. 24(4):1179-1183. Kentucky
- Wise, M. B., Barrick, E. R. and Blumer, T. N. 1965.  
Finishing Steers With Grain on Pasture.  
N. C. Agr. Exp. Sta. Bul. 425 North Carolina

Wise, M. B., Blumer, T. N., Craig, H. B. and Barrick, E. R. 1965.  
Influence of Rumen Buffering Agents and Hay on Performance and Carcass  
Characteristics of Steers Fed All-Concentrate Rations.  
J. Animal Sci. 24(1):83-88. North Carolina



## AREA NO. 5: DAIRY CATTLE - BREEDING

Problem. Dairymen need information on improved genetic methods for increasing and changing productive performance and efficiency in order to reduce unit costs and to meet current and future market demands. Precise information is needed on the relative importance of performance traits, the heritability of certain traits, sources of variation, nature of inheritance, response to selection, and systems of mating. Research is needed on milk and blood constituents, specific and general combining ability, heterosis and adaptability in order to reveal new genetic traits of economic importance and to develop new genetic methods of bringing about livestock improvement.

### USDA AND COOPERATIVE PROGRAM

This is a continuing program conducted by geneticists on basic and applied studies of the inheritance of the dairy cow, including experiments designed for evaluating the application of advanced genetic concepts to dairy cattle improvement. The work is in progress at Beltsville, Maryland, and cooperatively with experiment stations in 13 States and in laboratories in 17 foreign countries. Several of the studies contribute to the North Central and Southern regional dairy cattle breeding projects. Cooperation is also carried out with the National Association of Animal Breeders and with the various dairy cattle breed registry organizations.

The Federal scientific effort devoted to the research in this area totals 11.1 professional man-years. Of this number, 4.7 are devoted to genetics and interrelations of performance traits, and 6.4 to selection and systems of breeding.

A contract, involving \$20,000 annually, is in effect with the Wisconsin Agricultural Experiment Station to study the meat producing potential of dairy cattle.

A PL 480 grant for \$49,204 equivalent annually, at Turipana, Colombia, supports study of the relative performance of the native breed (Costeno Con Cuernos), Holsteins, and Brown Swiss under hot and humid conditions of Northern Colombia.

### PROGRAM OF STATE EXPERIMENT STATIONS

The total research effort on dairy cattle breeding by State agricultural experiment stations is 20.8 scientific man-years.

## PROGRESS -- USDA AND COOPERATIVE PROGRAMS

### A. Genetics and Interrelationships of Performance Traits

1. Breed characteristics independent of size. External and internal body measurements were studied in both Holstein and Jersey cows. The obvious differences between these two breeds are those associated with size. When the Jersey means were adjusted to Holsteins, a few characteristics independent of size were demonstrated. Jersey cows had lower values for thurl width, pin bone width, head length, head ratio, and shin bone circumference. They had higher values for rump length, length hips to pin bones and wedge in depth. These are external characteristics that could have been directly affected by selection to make animals conform to breed type or ideal. Breed differences independent of size were less noticeable among internal weights and measurements. This study indicates that effectiveness of selection in making breeds appear different from one another. It also shows how similar breeds are in their internal characteristics.

2. Anatomical differences in lactating and dry cows. In 183 Holstein and 193 Jersey cows slaughtered at Beltsville, dry cows were significantly higher in liveweight (5.16 and 4.05%) than lactating cows. Significant differences among external measurements were largely limited to higher values in dry cows for fore chest circumference (2.24 and 2.11% for Holstein and Jersey cows respectively), fore chest width (4.14 and 1.90%), rear chest width (2.96 and 1.82%), paunch width (4.77 and 3.52%), pin bone width (3.10 and 2.94%), and skin thickness (6.55 and 4.93%). Dry Jersey cows had significantly wider hips (3.42%) and thurls (1.85%) than lactating cows. In general, differences between lactating and dry cows in height, body length, depth of rear chest and paunch, head length and width, and shin bone circumference were not significant.

Lactating and dry effects were not alike on all internal anatomical characteristics. There were practically no significant differences between lactating and dry cows in thoracic cavity measurement, heart circumference, heart weight, spleen weight, or pancreas weight. In Holsteins and Jersey cows, the greatest and also highly significant differences between lactating and dry cows were the higher values in dry cows for empty body weight, carcass weight, hide weight, thoracic fat weight, and abdominal fat weight. In both breeds dry cows had significantly lower values than lactating cows for blood weight, kidney weight, liver weight, lung weight, total intestine length, and total stomach weight.

In general, dry cows had higher values than lactating cows for anatomical characteristics associated with fleshiness, and lower values for weights or measurements that might be associated with metabolic activity. Internal organs associated with milk production increased greatly in size during lactation.



3. Immature mammary development and subsequent udder conformation and lactation production. The ages at which connection of the mammary glands (front and rear) occurred were obtained for approximately 1800 Holstein-Friesian calves. Scores defining the distance between the mammary glands and the body wall (looseness) were recorded at five different ages and on 390 calves. Three udder type evaluation scores were made for each animal at 3 months after first calving and 3 months after calving as mature cows. Production performance included 305-day actual milk and butterfat yields for first and mature lactations. All correlation analyses were completed on a within-sire, herd, and year-season basis. Looseness scores were not correlated consistently with all measures of type and production; however, the correlation value for scores at 4 months with mature milk yield was .284.

The age at which mammary glands are connected was significantly correlated ( $r = .234$ ) with milk and fat yields of first lactation animals. Highly significant correlations were found for age of gland connection and 2 components of udder type ( $r = .645$  and  $.594$  for first lactation animals, and  $.705$  and  $.584$  for mature cows). The data suggest the use of age of connection of mammary glands of young heifers in estimating future udder type.

4. Genetic-environmental interactions in performance characteristics. In cooperation with the Utah State Experiment Station, a study is nearing completion which will determine the importance of genetic-environmental interactions as they relate to sire performance. Two hundred daughters of 14 sires have completed the study. One half of each sire group was fed a standard ration of forage plus concentrates while the other half received only forage throughout their complete first lactation. The data were analyzed to determine the comparative gross feed efficiency among the sire groups and between the two rations. Two measures of gross feed efficiency were used.

$$A = \frac{\text{Kg. FCM}}{\text{Kg. Dig. D.M.}}$$

$$B = \frac{750 \times \text{Kg. FCM}}{\text{K cal. energy consumed}}$$

Values of A ranged from 1.24 to 1.51 for sire groups on all forage and from 1.42 to 1.73 on normal rations. Values for B ranged between .22 and .26 for sire groups on all forage and between .25 and .30 on normal rations. Correlations were almost 1.0 between methods A and B for both rations. Correlations between production of FCM and methods A and B were .79 and .77, respectively.

Analysis of variance for unequal sub-class numbers indicated a highly significant difference between sires and between rations but a nonsignificant sire x ration interaction for both A and B. Cows receiving the all hay ration had the highest gross feed efficiency. This study shows that sires can be accurately ranked on merit of feed efficiency regardless of the type

of ration fed their daughters. It also shows that either method of defining feed efficiency is adequate, and that animals fed only forage are more efficient than those fed forage and concentrates. (AH gl-4)

5. Meat production from beef, dual purpose, and dairy steers. This study was initiated in cooperation with the Beef Cattle Research Branch to determine the relative merits of various breeds of cattle and different management systems in the production of beef. The period from birth to 180 days of age, for two experiments, has been completely analyzed. In experiment I, 65 controlled males were fed either on a high plane of nutrition involving large quantities of whole milk or a lower plane typical of raising dairy replacement heifers.

Results indicate significant differences among breeds, treatments, breed x treatment, periods, breed x periods, treatments x periods, and breed x treatment x periods for gain, therms consumed, feed efficiency and 180-day weight. The 180-day total gain on the high plane of nutrition was 404, 428, 323, and 286 lbs. for the Milking Shorthorn, Holstein, Angus, and Jerseys, respectively. The corresponding gain on the low plane of nutrition was 137, 195, 136, and 115 lbs. for the Milking Shorthorn, Holstein, Angus, and Jersey, respectively. The differences in total gain among breeds was a reflection of the total therms of energy consumed in both treatments. In the high plane of nutrition the Angus consumed the least amount whereas the Jerseys consumed the least on the low plane of nutrition. On the high plane of nutrition efficiency of feed utilization was 0.17, 0.17, 0.18, and 0.15 for the Milking Shorthorn, Holstein, Angus, and Jersey, respectively; on the low plane efficiency was 0.17, 0.19, 0.16, and 0.16 for the Milking Shorthorn, Holstein, Angus, and Jersey, respectively.

In the second experiment the amount of milk was reduced in the high level group. In the low level group the replacer was increased by 10% above the manufacturer's recommendations, and a commercial calf starter was fed from 14 to 90 days of age.

The data from 174 male calves in experiment two were analyzed in the same manner as experiment one. The results of the second experiment were similar to the first except that the breed x treatment interaction effects were not significant for efficiency of feed utilization. The 180-day gains on the high plane of nutrition were 420, 484, 351, and 321 lbs. for the Milking Shorthorn, Holstein, Hereford, and Jersey, respectively. The corresponding gains on the low plane of nutrition were 242, 279, 227, and 214 lbs. Efficiency of feed utilization on the high plane of nutrition was 0.16, 0.17, 0.15, and 0.15 for the Milking Shorthorn, Holstein, Hereford, and Jersey, respectively. The corresponding efficiency on the low plane of nutrition was 0.16, 0.17, 0.15, and 0.16. The differences in gain among breeds within treatments were a reflection of the total therms of energy consumed. The Holsteins consumed the most, followed by the Milking Shorthorns, Herefords, and Jerseys.



This study shows that Holstein steers can make larger gains in body weight than beef steers. They are also more efficient in feed utilization.  
(AH d3-6)

6. Genetics of milk constituents. A new technique of typing for  $\beta$ -casein variants in cows' milk was developed by workers at the Eastern Utilization Laboratory. Their results showed that  $\beta$ -casein A could be further subdivided by using polyacrylamide electrophoreses at acid pH.

Studies were initiated to see how the new variations would fit into the genetic scheme. The new typing technique was applied to milk samples from 1026 cows. Cows that previously showed "A" zone in alkaline electrophoresis often had two  $\beta$ -casein zones at acid pH but never three. The suggested genetic control and family studies indicated that there are at least five alleles at the  $\beta$ -casein locus rather than the original three. The new variants are now named  $A^1$ ,  $A^2$ , and  $A^3$  in order of their mobility at acid pH. The gene frequencies in the sample of 1026 cows were:  $A^1$  .29,  $A^2$  .63,  $A^3$  .02, B .05, and C .005. The  $A^3$  and C genes are quite rare. The B gene has not been found in Ayrshires, is rare in Guernseys and Holsteins, and relatively common in Brown Swiss (.17) and Jerseys (.30). As indicated by the overall gene frequencies,  $A^1$  and  $A^2$  are the most frequently found types. However, the variation between breeds in frequency of these two alleles is of interest. If order of  $A^1$  and  $A^2$  respectively they are: Ayrshire .75 and .25, Brown Swiss .13 and .68, Guernsey .005 and .99, Holstein .41 and .51, and Jersey .22 and .49. Studies of the relationship between  $\beta$ -casein and  $\alpha_{s1}$ -casein indicate that the two loci are closely linked on the same chromosome, but that some crossing-over does occur. These studies make a contribution to the store of knowledge on the action of specific genes in cattle and indicate how research on new techniques to identify variation can help in defining genetic control of specific traits. (AH g1-5)

7. Genetics of blood antigens and other biochemical polymorphisms in dairy cattle. A study was made in cooperation with the University of Minnesota on frequency of different transferrin genes in a Holstein population and how they relate to differences in milk production.

Gene frequencies for 1377 Holstein females in 12 herds, and for 222 Holstein bulls in 5 animal breeding studs, were similar. Combined estimates were .422, .554, and .024, for the transferrin A, D, and E alleles, respectively. Genotypic frequencies for 103 progeny of AD bulls, used in three experiment station Holstein herds, differed significantly from expectation, largely as a result of 55 AD X AD matings producing 1 AA, 31 AD, and 23 DD offspring. Results of matings between known parental types in six other institutional herds agreed with expectation.

First lactation milk and fat yields of 214 Holstein cows were expressed as deviations from herd mates, and regressed on number of transferrin D alleles to study the relationship between these variables. Records used

were from 6 State-owned herds, and from young cows among which virtually no selection had been practiced for yield. Intra-sire regressions of deviation milk and deviation fat on number of transferrin D alleles were  $-309 \pm 126$  and  $-9.1 \pm 4.8$  kg., respectively. Gross means for the 39 AA, 99 AD, and 76 DD cows involved were +465, +331, and +172 kg. for deviation milk, and +17.5, +12.9, and +11.5 kg. for deviation fat, respectively.

Animals with the E gene were too few to study. These results indicate a strong association between transferrin genes and milk and fat production.

At Ohio a study was made to determine associations between blood antigen type and estimated breeding values (predicted differences) of well sampled Jersey sires. Records from 262 sires with a total of 46,041 daughters, and each having a USDA derived predicted difference, were analyzed. A significant relationship between bulls blood type and predicted difference was found in the B and S systems for pounds of milk and fat and in the Z system for percent fat. Bull-year-of-birth and sire equations were absorbed in the B and S systems to remove these effects as a possible source of variation. Bull-year-of-birth absorption had little effect on the relationships, but upon removal of between sire effects, the relationships were no longer significant. This suggests that the association found may be due to variation in gene frequency among 1/2 sib families (sire groups) represented in the sample rather than a direct effect of the alleles upon the production traits. This study emphasizes the futility of selecting young bulls as service sires based upon their own blood type. (AH gl-6)

8. Meat from dairy and beef steers. A contract with the University of Wisconsin involves a comparison of Holstein and Hereford breeds for performance characteristics in producing meat. Steers are fed on either a high or medium plane of nutrition. During the growth period of 500 to 750 lbs. body weight, 18 Hereford steers on the medium ration gained 1.99 lbs. per day and consumed 4.57 lbs. of grain dry matter and 1.41 lbs. of hay dry matter for each pound of gain. Nine Holsteins under similar conditions gained 2.08 lbs. per day with dry matter consumption of 4.33 and 0.77 lbs. of grain and hay, respectively, for each pound of gain. High plane of nutrition feeding resulted in daily gains of 2.42 lbs. for Herefords and 2.80 lbs. for Holsteins with the latter requiring slightly less feed per pound of gain.

When the steers were compared for the growing period of 750-1000 lbs. body weight, results were similar regardless of the plane of nutrition. These preliminary data suggested that Holsteins grow faster and slightly more efficient than Herefords under both medium and high planes of nutrition. Carcass traits have not yet been evaluated. (AH gl-9)

9. Relationships of beef and dairy characteristics in Milking Shorthorn cattle. In cooperation with the University of Minnesota, a project is in progress to evaluate the effectiveness of selection for milk production and concurrent changes in meat producing ability in Milking



Shorthorn cattle. The herd has made remarkable increases in production, moving from 8,143 lbs. of milk and 293 lbs. of milk-fat in 1960, to 12,361 lbs. of milk and 486 lbs. of milk-fat in 1966. Much of this increase has been due to rigid culling and an environment favorable to milk production. Part is also due to the use of superior proven sires, especially from two bulls whose semen was imported from New Zealand.

Shorthorn steers were compared to Holstein steers for meat producing ability. Shorthorn steers gained more slowly and required slightly more feed per 100 lbs. of gain than the Holsteins. They graded 2/3 of a grade higher, however, and returned about \$5.00 more per steer over initial cost and feed cost than Holsteins. This study indicates favorable milk production from Milking Shorthorn cattle when they are given adequate opportunity and when they are sired by good, proven bulls. Steers from this breed have a slight advantage over Holsteins in total return on investment.

10. The importance of immunogenetic factors in problems of lowered fertility in cattle. In cooperation with the Biophysics Branch of the Armed Forces Institute of Pathology, Walter Reed Army Medical Center, a study is underway aimed at separating sperm cells into different components based on their weight differences. These weight differences from sedimentation columns could be related to cells producing either male or female progeny. Results of 75 sedimentation columns failed to indicate that sperm could be separated consistently into two different populations by the technique described in the literature. These findings are at variance with the published reports in important details: 1) Fractions cannot be removed from the bottom of burettes since in most cases the material in the center of the columns is withdrawn sooner than material at the sides. 2) A standard viscosity of sedimentation medium and time of sedimentation cannot be used because of variations between bulls and ejaculates within bulls. Fractions are now removed from the top of the column by pipette. Studies are continuing in an attempt to find a repeatable method of separating sperm into two groups on the basis of the sex chromosome they possess. (Ah g1-7)

11. Effect of autoimmunization with semen on sperm production by young dairy bulls. In 1964, this report gave an account of studies which attempted to produce aspermatogenesis in bulls by immunization of the bulls with their own semen. Six bulls were injected every week and were ejaculated nine times a week (every other day, three ejaculates per day) but no effect on spermatogenesis was noted. Results of later studies on three bulls at Rutgers University indicated that spermatogenesis was adversely affected. The Rutgers study involved fewer injections and semen collection at weekly intervals. The reason for the apparent difference in results between the two studies is not known, but one hypothesis is that bulls in the Beltsville study were injected so often that they became immunologically "tolerant" rather than sensitive to the semen antigens. Therefore, 4 young dairy bulls were injected intradermally with their own semen, in Freund's adjuvant, 4 times over a 4-month period and semen was

collected once a week (three ejaculates each time). This was approximately the same procedure used at Rutgers. However, this treatment did not affect sperm motility, concentration, or semen volume. These results confirm the results of the first Beltsville study and indicate that bulls, unlike guinea pigs, do not become aspermatogenic when immunized with their own semen. (AH g1-7)

## B. Selection and Systems of Breeding

1. Comparisons of inbreeding and outbreeding. In cooperation with the University of Wisconsin, a study has been underway to evaluate systems of mating with six inbred lines of Holstein cattle and crosses among these inbred lines.

The production characteristics studied were milk, solids-not-fat (SNF), and milk fat yields, as well as percent SNF and milk fat. Yields were expressed as deviations from random outbred controls. Of the individuals studied, there were: 77 from inbred lines, 79 from two-line crosses, 78 from three-line crosses, and 41 from four-line crosses. The average deviations from M.E. milk yield were: -1013 kg., -320 kg., -421 kg., and -542 kg. for the four groups, respectively. The average yield of M.E. milk for 137 controls was 6542 kg. Models were fitted to the data to provide estimates of heterosis, differences among inbred lines, general combining ability of each line, maternal effect of each line, differences among sires within lines and differences among sires within line crosses. In general, the line crosses were 15% superior to the inbreds for the characteristics studied. Statistically significant differences among general combining abilities of the lines were observed in two-line and three-line crosses but not in four-line crosses. No significant maternal effects were observed.

Although crossing of specific inbred lines may produce superior individuals for milk production, the development and maintenance of inbred lines is too costly to recommend this system of mating for dairy cattle breeders. (AH g2-5)

2. General and specific combining ability. In cooperation with Ohio State University and the University of Minnesota, studies are in progress to evaluate the usefulness of specific combining ability and inbreeding in dairy cattle. In the analysis of weight data, constants were fitted for the mean, years, type of breeding, general combining ability, sires, herds, linebreds, specific combining ability, reciprocal effects, sire X type of breeding interaction, and the regression of weight on age since the measurements were taken at 3 months (+ or - 10 days). General combining ability was estimated from the linebred as well as linecross cells. Analysis of variance indicated that the only effects significant were years, herds, and the regression of weight on age. This preliminary analysis shows no beneficial effect on body weight by crossing inbred lines.



A study was made to determine changes in the degree of homozygosity of genetic polymorphisms with inbreeding. The degree of observable homozygosity at the  $\beta$ -lactoglobulin, serum transferrin, and blood antigen A, F, J, L, and Z loci was calculated within inbred lines for groups of animals at different inbreeding levels, and compared with the calculated inbreeding coefficient. Three unrelated lines of Holstein cattle containing 71, 99, and 101 animals, respectively, and varying in inbreeding values from zero to 25%, were each divided into 5 or 6 groups according to inbreeding level. Percent homozygosity was determined for each group. All lines increased in observable homozygosity with increasing inbreeding level. Since the changes appeared to vary in a linear fashion, least squares methods were employed to fit straight lines. The fitted lines indicated that for each increase of .01 in inbreeding, the decreases in heterozygosity relative to that of the outbred foundation animals were 0.3%, 1.2%, and 2.4% in the three lines. In a fourth line containing 109 animals where inbreeding values were lower, and only two levels were present, homozygosity was slightly lower at the 10% than at the zero inbreeding level. It is concluded that despite the considerable amount of variation not accounted for by any linear relationship between homozygosity of blood and milk loci and inbreeding coefficient, the main tenets of inbreeding theory are supported. Thus, at these rather low levels of inbreeding in cattle, the observed blood and milk loci appear to behave as generally predicted by inbreeding theory with no good evidence for deviation from the expected linear relationship.

At Minnesota, a study was made to determine the influence of sire's inbreeding on family variance. Variances among daughters of inbred and noninbred sires were examined to evaluate the breeding system that produced the sire. Variances were estimated from progeny records expressed as deviations from herdmates and adjusted for environmental trends. Each of the 431 Holstein sires studied had a minimum of 200 production tested daughters resulting from artificial insemination. Sires were grouped by level of inbreeding with the mean inbreeding coefficient at the three levels being: (H) .1569, (M) .0586, and (L) .0016 with 46, 105, and 280 sires in the three respective groups. It was concluded that the breeding value of inbred bulls is much more variable than the breeding value of outbred sires. The best and poorest sires were among the most highly inbred. Selection of inbred bulls for sampling in A.I. would improve chances for obtaining the very top bulls. (AH g2-22)

3. The influence of parental relationship on the genetic merit of dairy cows and sires. A study was initiated to determine the growth characteristics of female progeny resulting from a breeding project designed to evaluate the relative merits of three mating systems; closed herd, outcrossing, and crossbreeding. Progeny tested sires of high individual merit were used as service sires in each of the three systems. Body weight and measurement traits were taken at 6, 12, and 16 months of age and 90 days post-partum of the first lactation. In addition to body

weights taken at these ages, other specific traits included birth weight, height at withers, depth of forechest and paunch, and lengths from withers to pins at each of the indicated ages.

In comparing the various breed groups by ages for those traits in which there were significant group differences, it was apparent that the Swiss x Holstein crosses were significantly larger than the other cross-bred groups at 12 months and 16 months of age and at 90 days post-partum. They were also significantly larger than the closed herd groups in 12 and 16 month body weight and at 90 days post-partum. In addition, the closed herd group was significantly larger than Ayrshire x Holstein crosses in birth weight, body weight, height at withers, depth and circumference of forechest at 12 months, 16 months, and 90 days post-partum. At 16 months of age the closed herd group was also significantly different from the Ayrshire x Holstein crosses for both of the length measurements. In general, it can be concluded that Swiss x Holstein crosses were larger than any of the other groups at all ages in most of the traits and the Ayrshire x Holstein crosses were smaller.

The relationships between rate and efficiency of gain on growing heifers and subsequent production traits in first lactation were determined for each of the mating system groups. Heifers were fed alfalfa hay ad libitum and 3.0 lbs. of concentrate daily for 120 days between 12 and 16 months of age. There was a significant difference among groups for 120-day gain and total therms consumed. The Swiss crosses ranked first and the Ayrshire crosses last. There was no difference among groups in feed efficiency. It appeared that differences in gain are a result of appetite differences.

The results of within sire correlation analysis between the 12-16 month growth traits and the first lactation production traits showed a significant positive correlation between 120-day efficiency in gain and efficiency of production (0.21). There was a significant negative correlation between therms consumed during the growth period and efficiency of milk yield (-0.24). This study shows little possibility for predicting milk production from growth characteristics of heifers. It also indicates only a slight genetic relationship between meat and milk production. (AH g2-24)

4. Comparison of genetic methods of using sires available in artificial breeding. In cooperation with the University of Minnesota, a study is in progress with Guernsey cattle to measure production trends resulting from the use of highly proven outcross A.I. sires as compared to using line-bred A.I. sires. Data from the offspring of three highly proven bulls are available. Based on their determined breeding values, their daughters should exceed their herdmates by 968 lbs. of milk. In this test their 39 daughters averaged 1681 lbs. milk and 60 lbs. milk fat more than the linebred herdmates. This study illustrates the potential increases in milk production possible by using superior A.I. sires. (AH g2-26)



5. Usefulness of heterosis resulting from interbreed matings.

(a) Relation of body weight and age to first lactation yield.

In cooperative work at Illinois, body weight, age at the time of first calving, and days carried calf during lactation were studied in relation to first lactation milk, FCM, and fat yield. Holsteins, Guernseys, and three crossbred groups involving these breeds were included. Age of calving, when included with days carried calf as the only additional covariate, was significantly associated with all production traits. Body weight was also associated with production. When age and weight were included as additional covariates, the independent relationship of yields with age became trivial. Lactation milk yield increased 395 kg. with each 100 kg. increase in body weight at calving time but neither weight nor age was related with milk fat percent. Lactation yields of milk, fat, and FCM seemed to vary as the 0.6 power of body weight at calving. These findings suggest that body weight at time of calving should be taken into consideration in evaluating the performance of crossbreds versus purebreds. (AH g2-23)

(b) The effect of crossbreeding on birth weight and early growth rate.

At Beltsville the average birth weight of female calves of 2- and 3-breed crosses among Ayrshires, Brown Swiss, and Holsteins exceeded the parental mean by 1-10%. Parity, breed of sire, breed of dam, and the breed of sire by breed of dam interaction had important effects on birth weight. Two breed crosses produced from mating Brown Swiss and Holstein sires to Ayrshire cows, and Holstein sires to Swiss cows averaged 6-9 lbs. lighter at birth (82 lbs.) than the reciprocal crosses (88-91 lbs.), but by 6 months of age, the smaller calves were slightly heavier (393 vs. 379 lbs.). In the three breed crosses, the breed of dam by breed of sire interaction also had a significant influence on birth weight but again by 6 months the smaller calves were heaviest (389 vs. 368 lbs.). After 6 months, breed of sire had a significant effect on growth rate but maternal effects were not important. The average birth, 3, and 6 month weights for the 6 types of two-breed crosses and the 6 groups of three-breed crosses were similar. The results indicate birth weights of 88 or more pounds afford no advantage in the early development of dairy calves, and 3-breed crosses show no superiority over two-breed crosses in growth rate. (AH g2-23)

6. Genetic methods for developing adaptability.

(a) Importance of calf mortality in determining rate of female selection.

At Louisiana State University, 613 pregnancies resulted in 4.3% abortions, 3.1% stillbirths, and 95.7% terminal pregnancies. The sex ratio was 46.9% female calves. Of the female calves born alive, 84.7, 81.8, and 76.4% were in the herd at 3 months, 17 months, and at first calving, respectively. The average number of lactations initiated per cow during her lifetime was 3.7; thus, 80.7% of the females born were needed for replacements to maintain a stationary herd size. (AH g4-2)

(b) Morbidity and mortality losses. At the Iberia Livestock Experiment Station, Jeanerette, Louisiana, the losses in milk production and animals from clinical anaplasmosis in 1964 were \$9660 and losses in 1965 were about \$6000. Testing of a vaccine to reduce the severity of infection and economic losses was begun in 1965, but results from the first year are not encouraging. This effort is a part of the adaptability work underway at this station. (AH g4-2)

(c) Systems of breeding for improvement of adaptability in Holsteins. At Louisiana State University, preliminary comparisons of the performance of a herd of Holsteins, produced by continued outbreeding to AI proved sires from studs throughout the U.S. to that of a closed herd of Holsteins, showed no substantial difference in average milk yield. The average M.E. yield for the closed herd was 6668 kg. milk and 228 kg. fat and for the open herd 6458 kg. milk and 220 kg. fat. (AH g4-2)

(d) Crossbreeding for improvement of adaptability. At Jeanerette, the purebred Holsteins continue to give slightly higher milk and SNF yields (+8%) than crossbreds produced by mating Holstein sires to Jersey or Red Sindhi crossbred cows, or by mating Brown Swiss sires to Jerseys, Red Sindhi crossbreds, or Holstein females. The milk fat yield of the crosses was, however, slightly higher (+6%). The average first lactation yields of crossbreds, produced by mating crossbred sires to crossbred females, were poor in comparison to the crosses by purebred sires and purebred Holsteins, -20% for milk, -24% for SNF yield, and -12% for milk fat. Breed of sire effects were significant, indicating crossbreds sired by Holstein bulls give higher milk yields than crossbreds sired by either Brown Swiss or crossbred bulls.

Reproductive efficiency, as measured by the number of days from parturition to first estrus, days open, calving interval, and the percentage of cows that conceived by 95, 120, and 145 days after calving, showed no distinct superiority for crossbreds over purebreds at either Jeanerette, Louisiana, or Reidsville, Georgia. At Jeanerette, there was no consistent difference between crossbreds, sired by Holstein and Brown Swiss sires, and purebred Holsteins in days open, calving interval, or services for conception, but all three measures were significantly affected by season. At Reidsville, direct comparisons of reproductive efficiency between crossbreds and purebreds were affected by the abnormally low fertility of the Brown Swiss. These results suggest that crossbreds may conceive to an earlier service as heifers or after calving, but this difference was not sufficient to be reflected in a shorter average interval between calving and conception. Furthermore, crossbreeding does not appear to enhance breeding efficiency under southern Louisiana and southeast Georgia conditions.

In the Reidsville herd, the Brown Swiss were the heaviest at birth and at 3 months of age, but afterwards Holsteins weighed more. There was no evidence of heterosis among the body weights of the crossbreds; however, the growth potential of some groups could have been depressed due to limited



feeding during this period. The crossbreds were heavier than the weighted average of the parental breeds from 6-21 months of age by 3-10%; yet, none of the crossbred groups equaled or surpassed the Holsteins in growth. Unless the crossbreds offer distinct advantages in efficiency of growth, there seems to be little merit for crossbreeding in Holstein populations. (AH g4-2)

(e) Growth rate of heifers at Jeanerette, Louisiana. Holstein and crossbred heifers grew at a normal rate from birth to 6 months of age but when they were put on pasture at 6-8 months of age, growth rate slowed down even though feeding of concentrates and forages was continued at a rate to support normal gains. At 12 months of age, body weights were 15-20% below expectations. From 12-24 months rate of gain was again near normal; however, the animals failed to make compensating gains and at 24 months were approximately 150 lbs. below expected. These patterns of growth rate were similar for both crossbreds and Holsteins. It is postulated that the major factor in the poor gains from 6-12 months was the effect of internal parasites on efficiency of feed utilization. Studies have been initiated to investigate this problem. (AH g4-2)

(f) Jersey-Brahma crossbreds for dairy production. At Texas A&M University, a search for Jersey-Brahma crossbred sires that will transmit high levels of milk yield has not been successful. Five crossbred bulls have produced five or more tested daughters, but in each sire group 45% or more of the females were culled for low production. In most cases, the crossbreds failed to produce more than 6.8 kg. of milk per day after calving. A few made 305-day milk records between 898 and 2694 kg. These started second records at an equal or lower level and were culled. The low average milk yield, the high variability, and poor temperament of the progeny of crossbred sires have been similar to that of the 1/2, 3/4, and 7/8 Jersey-Brahma crosses. In view of the results, this phase of breeding for improvement of adaptability to the South has been terminated. (AH g4-2)

(g) Dairy merit of Criollo cattle in Colombia. In seeking to determine the potential for dairy production of breeds native to Colombia, 1357 calvings of 514 females of a Criollo breed, Blanco Orejinegro, were studied. As with the Consteno Con Cuernos breed, the average lactation milk yield was low, 218 kg., and highly variable. The greatest frequency of lactation yields occurred in the 0-45 kg. class (49%). The total repeatability of milk yield over the first three lactations was 0.63 and the estimated heritability of first lactation milk yield was 0.27. The distribution of lactation length was similar to that for total milk yield. Lactation length was one of the more important factors determining total yield, unlike the situation in temperate zone breeds. Year effects accounted for less than 10% of the variation in milk yield but seasonal effects were significant.

Improvement in milk yield followed the beginning of the wet season by about 2 months, but the heaviest rains in October and November depressed production. The average age of first calving was 41 months and the mean calving interval was 403 days. The most significant finding in this study is the extremely low level of milk production. Low energy intake and water supply no doubt limited yields, but the performance of crossbreds in the same herd indicates that genetic causes were strongly to blame for the poor general level of performance. As in the case of the Costeno Con Cuernos, refusal to let down milk was a factor. It is concluded that even though the heritability of milk yield may be equivalent to that of temperate zone breeds, the range of yield reached by the best 10% of the cows (680-1856 kg.) does not reflect an economically justifiable level. This evidence will need further confirmation but it appears that, as with the Costeno Con Cuernos breed, the Blanco Orejinegro has limited utility for dairy production in the tropics. (S5-AH-1)

#### PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

##### Genetics and Interrelationships of Performance Traits

- Hines, H. C. 1965. An examination of some bovine typing antibodies by gel-filtration analysis. Immunogenetics Letter 4(2):85-90. (AH gl-6)
- Hines, H. C., Ludwick, T. M., and Rausch, W. H. 1965. Physical and biochemical properties of bovine transferrins associated with genetic control mechanisms. Immunogenetics Letter 4(2):81-85. (AH gl-6)
- Kiddy, C. A., Peterson, R. F., and Kopfler, F. C. 1966. Genetic control of the variants of  $\beta$ -casein A. J. Dairy Sci. 49:742 (Abs.). (AH gl-5)
- Lamb, R. C. and Anderson, M. J. 1966. Comparative gross feed efficiency in 14 Holstein sire groups. J. Dairy Sci. 49:735 (Abs.). (AH gl-4)
- Miller, K. P., Meiske, J. C., Davidson, W. D., Young, C. W., Hanson, L. E., and Cole, C. L. 1966. A comparison of different proportions of concentrate and hay fed Holstein and Milking Shorthorn steers. Minn. Science Jan. 1966. (AH dl-27)
- Rausch, W. H., Brum, E. W., and Ludwick, T. M. 1966. Association between blood antigen type and artificial insemination proof of Jersey sires. J. Dairy Sci. 49:742 (Abs.). (AH gl-6)
- Rausch, W. H., Brum, E. W., Hines, H. C., and Ludwick, T. M. 1965. Cattle blood type phenogroup frequencies in Ohio NC-2 herds. Immunogenetics Letter 4(2):76-80. (AH gl-6)



- Rausch, W. H., Ludwick, T. M., and Weseli, D. F. 1965. Determination of bovine transferrin types by disc electrophoresis. J. Dairy Sci. 48:720-725. (AH g1-6)
- Rausch, W. H., Ludwick, T. M., and Weseli, D. F. 1965. Inheritance of bovine transferrin types as determined by disc electrophoresis. J. Dairy Sci. 48:990-991. (AH g1-6)
- Thatcher, W. W. 1965. The occurrence and interrelationships of milk protein, serum transferrin, and blood group polymorphisms in cattle. M.S. Thesis, University of Maryland. (AH g1-5)
- Thatcher, W. W. and Kiddy, C. A. 1965. Associations among blood groups and milk polymorphisms in dairy cattle. J. Dairy Sci. 48:1558 (Abs.). (AH g1-5)
- Young, C. W. and Hunter, A. G. 1966. Transferrin polymorphism studies in Holstein cattle. J. Dairy Sci. 49:735 (Abs.). (AH g1-6)

#### Selection and Systems of Breeding

- Bereskin, B. and Touchberry, R. W. 1966. Crossbreeding dairy cattle. III. First lactation production. J. Dairy Sci. 49:659-667. (AH g2-23)
- Bereskin, B. and Touchberry, R. W. 1966. Some relationships of body weight and age with first-lactation yield. J. Dairy Sci. 49:869-873. (AH g2-23)
- Branton, C., Evans, D. L., Waters, W. H., and McDowell, R. E. 1966. Breeding Holsteins for productive adaptability in the Gulf Coast area. J. Dairy Sci. 49:724 (Abs.). (AH g4-2)
- Conlin, B. J. 1966. Environmental and genetic variation among and within sire families in an artificial insemination population. Ph.D. Thesis, University of Minnesota. (AH g2-22)
- Conlin, B. J. and Young, C. W. 1966. Influence of sire's inbreeding on family variance. J. Dairy Sci. 49:721 (Abs.). (AH g2-22)
- Davis, D. R., Ludwick, T. M., Hines, H. C., and Barker, K. L. 1965. Variations in S-GOT and S-GPT in cycling cows. J. Dairy Sci. 48:806 (Abs.). (AH g2-22)
- Hines, H. C., Brum, E. W., and Ludwick, T. M. 1966. Changes in degree of homozygosity of bovine blood and milk polymorphisms with inbreeding. J. Dairy Sci. 49:735 (Abs.). (AH g2-22)

- Holtman, W. B., and Tyler, W. J. 1966. Production performance of inbred lines and line crosses of dairy cattle. J. Dairy Sci. 49:722 (Abs.). (AH g2-5)
- Hooven, N. W., Jr., Plowman, R. D., and Miller, R. H. 1966. Relationships between growth and production traits of Holstein and crossbred females. J. Dairy Sci. 49:723 (Abs.). (AH g2-24)
- Lamb, R. C. 1966. Incomplete terminal records for sire evaluations. J. Dairy Sci. 49:748 (Abs.). (AH g2-5)
- Markos, H. G. and Touchberry, R. W. 1966. Heritability of maximum and initial rate of milk flow and milking time. J. Dairy Sci. 49:722 (Abs.). (AH g2-23)
- Martin, T. G. and Starkenburg, R. T. 1965. Genetic correlations between beef and dairy traits in dual-purpose cattle. World Rev. An. Prod. 1: 45-52. (AH g2-23)
- McDowell, R. E. and Smith, J. W. 1966. The future of animal breeding for resistance to disease and pests. ARS 33-110, p. 148-155. (AH h3-12)
- Plowman, R. D., Hooven, N. W., Jr., and Miller, R. H. 1966. Comparison of growth characteristics among Holstein and crossbred females. J. Dairy Sci. 49:722 (Abs.). (AH g2-24)
- Touchberry, R. W. and Bereskin, B. 1966. Crossbreeding dairy cattle. II. Weights and body measurements of purebred Holstein and Guernsey females and their reciprocal crossbreds. J. Dairy Sci. 49:647-658. (AH g2-23)
- Touchberry, R. W. 1966. Effects of stage of lactation and yield of milk on milk flow and time required to milk. J. Dairy Sci. 49:722 (Abs.). (AH g2-23)



### Related Publications of State Experiment Stations

Allaire, F. R. and Gaunt, S. N. 1965. First Lactation Contemporary Comparisons as Indicators of Environmental Influences on Daughter Records Used for Sire Evaluation. J. Dairy Sci. 48(4): 454-461. Massachusetts

Allaire, F. R. and Henderson, C. R. 1965. Inbreeding Within an Artificially Bred Dairy Cattle Population. J. Dairy Sci. 48(10): 1366-1371. New York

Allaire, F. R. and Henderson, C. R. 1965. Specific Combining Abilities Among Dairy Sires. J. Dairy Sci. 48(8):1096-1100. New York

Bereskin, Ben and Freeman, A. E. 1965. Genetic and Environmental Factors in Dairy Sire Evaluation. I. Effects of Herds, Months, and Year-Seasons on Variance Among Lactation Records: Repeatability and Heritability. J. Dairy Sci. 48(3):347-351. Iowa

Bereskin, Ben and Freeman, A. E. 1965. Genetic and Environmental Factors in Dairy Sire Evaluation. II. Uses and Limitations of Deviation Records and the Role of Dams. J. Dairy Sci. 48(3): 353-355. Iowa

Bereskin, Ben and Lush, J. L. 1965. Genetic and Environmental Factors in Dairy Sire Evaluation. III. Influence of Environmental and Other Extraneous Correlations Among the Daughters. J. Dairy Sci. 48(3):356-360. Iowa

Boyd, L. J. and Hafs, H. D. 1965. Body Size of Calves from Holstein Dams and Sired by Holstein or Angus Bulls. J. Dairy Sci. 48(9):1236-1240. Michigan

Datta, S. P., Stone, W. H., Tyler, W. J., and Irwin, M. R. 1965. Cattle Transferrins and Their Relation to Fertility and Milk Production. J. Animal Sci. 24(2):313-318. Wisconsin

- Deaton, O. W. and McGilliard, L. D. 1965. Weighting Information from Relatives to Select for Milk in Holsteins. J. Dairy Sci. 48(3):365-369. Michigan
- Everett, R. W. and Magee, W. T. 1965. Maternal Ability and Genetic Ability of Birth Weight and Gestation Length. J. Dairy Sci. 48(7): 957-961. Michigan
- Fosgate, O. T. 1965. Rate, Age, and Criteria for Disposal in a Herd of Registered Jersey Cattle. J. Dairy Sci. 48(11):1481-1484. Georgia
- Gangwar, P. C., Branton, Cecil and Evans, D. L. 1965. Reproductive and Physiological Responses of Holstein Heifers to Controlled and Natural Climatic Conditions. J. Dairy Sci. 48(2):222-227. Louisiana
- Hilliers, J. K. and Freeman, A. E. 1965. Differences Between Sires in Rate of Maturity of Their Daughters. J. Dairy Sci. 48(12):1680-1683. Iowa
- McDaniel, B. T. and Legates, J. E. 1965. Associations Between Body Weight Predicted from Heart Girth and Production. J. Dairy Sci. 48(7):947-956. North Carolina
- Mi, M. P., Chapman, A. B. and Tyler, W. J. 1965. Effects of Mating System on Production Traits in Dairy Cattle. J. Dairy Sci. 48(1):77-84. Wisconsin
- Plum, Mogens, Andersen, Henry and Swiger, L. A. 1965. Heritability Estimates of Gestation Length and Birth Weight in Holstein-Friesian Cattle and Their Use in Selection Indexes. J. Dairy Sci. 48(12): 1672-1675. Nebraska
- Schmidt, G. H. and VanVleck, L. D. 1965. Heritability Estimates of Udder Disease as Measured by Various Tests and Their Relationship to Each Other and to Milk Yield, Age, and Milking Times. J. Dairy Sci. 48(1):51-55. New York
- Sweetman, W. J. May 1965. Dairy Herd Improvement by Introducing High Milk Production into a Herd of High Testing Cows. Alaska Agr. Exp. Sta. Bull. 36. Alaska
- Tucker, W. L. and Legates, J. E. 1965. Seasonal Division of Herd-Mates in Sire Evaluation. J. Dairy Sci. 48(2):234-242. North Carolina
- VanVleck, L. D. and Albrechtsen, R. 1965. Differences Among Appraisers in the New York Type Appraisal Program. J. Dairy Sci. 48(1):61-64. New York



- VanVleck, L. D. and Bradford, G. E. 1965. Comparison of Heritability Estimates from Daughter-Dam Regression and Paternal Half-Sib Correlation. J. Dairy Sci. 48(10):1372-1375. New York
- VanVleck, L. D. and Burke, J. D. 1965. Production Differences Between Registered Cows and Their Nonregistered Herd-Mates. J. Dairy Sci. 48(7):962-967. New York
- VanVleck, L. D. and Hart, C. L. 1965. Heritability Estimates When Dams and Daughters are in the Same and Different Herds. J. Dairy Sci. 48(12):1676-1679. New York
- VanVleck, L. D. and Hart, C. L. 1965. Linearity of Heritability of Holstein First-Lactation Milk Production. J. Dairy Sci. 48(10):1376-1377. New York
- White, J. M. and Nichols, J. R. 1965. Relationships Between First Lactation, Later Performance, and Length of Herd Life in Holstein-Friesian Cattle. J. Dairy Sci. 48(4):468-474. Penna.

## AREA NO. 6: DAIRY CATTLE - PHYSIOLOGY

Problem. Fundamental physiological research is required as a basis for improving reproductive and lactational performance of cattle. Breeding failure is a major reason for the disposal of cattle, and results in great economic loss to farmers. Further information is required on the physiological action of hormones in controlling the reproductive process, correcting reproductive abnormalities, and stimulating lactation. Research is also required on physiological processes related to growth and development, nutritional and management requirements, and on heat tolerance of dairy cattle.

### USDA AND COOPERATIVE PROGRAM

This is a continuing program, largely in basic research, conducted by physiologists and biochemists. The program is designed to elucidate the reproductive and lactational physiology of cattle, utilizing physiological and biochemical techniques, and to determine physiological mechanisms related to heat tolerance. The work is in progress at Beltsville, Maryland, and cooperatively at the Wisconsin Experiment Station.

In 1965-1966 funds in the amount of \$73,869 from the National Institutes of Health supported largely basic research on physiological reactions, to ovarian blockage and to devices in the uteri of animals. (Also in Area 1)

Continuing PL 480 grants supporting research in dairy cattle physiology include: \$15,568 equivalent annually at Picassununga, Brazil, for study of structural and physiological characteristics associated with adaptability in tropical and subtropical areas; \$39,497 equivalent annually at Izatnagar, India, for study of the physiology and genetics of adaptability of cattle and buffalo; \$11,541 equivalent annually at Karnal, India, for study of nutritional physiology of different breeds of Indian cattle; \$30,699 equivalent annually at Beit Dagan, Israel, for comparative studies of "repeat breeders" and normal cows and heifers; and \$24,636 equivalent annually at Jerusalem, Israel, for study of the mechanism of lactation.

A new PL 480 project at Anand, India, was initiated in 1965. This five-year study supported at \$18,948 equivalent annually is aimed at ovarian function and its experimental control in the water buffalo.

The Federal scientific effort devoted to the research in this area totals 5.0 scientific man-years. Of this number 3.9 are devoted to the physiology of reproduction, and 1.1 to environmental physiology.



## PROGRAM OF STATE EXPERIMENT STATIONS

The total research effort on dairy cattle physiology by State agricultural experiment stations is 36.0 scientific man-years.

### PROGRESS -- USDA AND COOPERATIVE PROGRAMS

#### A. Physiology of Reproduction

1. Anti-fertility effects of mechanical devices in the uterus. At Beltsville, plastic spirals were inserted through the cervix into one or both uterine horns of parous cows. The cows were found to be infertile after natural breeding with spirals in both horns. Pregnancies resulted in cows with spirals only in one horn when ovulation occurred on the opposite ovary.

In a study of ovum fertilization, cows were slaughtered 3 days post-breeding. In cows with spirals in both horns, the fertilization rate was higher in those bred naturally (8 of 10 ova) than in those bred artificially (1 of 7 ova). This difference was probably due either to greater numbers of sperm entering the uterus after natural breeding or to factors associated with the psychological stimulus of natural mating. In cows bred artificially with a spiral only in one horn, the fertilization rate was higher when ovulation occurred opposite the spiral (8 of 8 ova) than when ovulation was adjacent to the spiral (1 of 4 ova). These results show that the anti-fertility action of an intra-uterine device in the cow differs with type of mating; a spiral primarily inhibits ovum fertilization after artificial insemination and inhibits embryo survival after natural breeding. A spiral does these things only in its own uterine horn, and does not interfere with ovum fertilization or embryo survival in the opposite horn. These results clearly indicate that inhibition of ovum fertilization after artificial insemination is due to a localized mechanism, probably to mechanical obstruction of sperm transport.

Studies with ewes indicated that a spiral in one horn inhibited sperm transport and ovum fertilization on both sides of the reproductive tract, and that these effects were due to something other than mechanical interference with sperm transport. After injecting semen into anterior uterine horns, 7 of 8 ova recovered from 5 "spiral" ewes were fertilized, as were each of 7 ova from 5 control ewes, but the number of accessory sperm in the ova averaged 122 for control ewes and 7 for "spiral" ewes. Five hours after injection of 150-200 million sperm cells into ligated uterine compartments, only 23.1% of the sperm recovered 5 hours later from spiral compartments in 8 ewes were intact; 79.4% of the sperm recovered from non-spiral compartments of the same ewes were intact. Results indicate that spirals inhibit sperm transport following natural mating, and promote spermicidal conditions in the uterine lumen. (AH h5-8)

Cooperative work at Wisconsin indicates that intra-uterine devices (IUD) in the cranial portion of one uterine horn exert a unilateral inhibitory influence on the corpus luteum in both heifers and ewes, thus involving a utero-ovarian relationship. Similar results were obtained with guinea pigs. It appears, therefore, that uterine functions are changed in some way by IUD. At Beltsville studies were made of the acid and neutral mucopolysaccharide content of the endometrium of cows with IUD. Means for nonspiral and spiral areas differed significantly, indicating a marked localized effect of the spiral on endometrial ground substance. (AH h5-6; h5-8)

Studies of the effect of IUD and gonadotropic hormone on the corpus luteum (CL) of the ewe indicate that spirals in the anterior or posterior portion of the uterine horn interfere with the development of the CL in the adjacent ovary but not in the opposite ovary. Injections of human chorionic gonadotropin hormone yielded results indicating that the presence of a mechanical device in either end of a uterine horn inhibits the development of the CL, but that the CL is responsive to the stimulatory effect of injected gonadotropin. Spirals in the uterine lumen also interfered with CL development in ewes from which the oviducts had been removed. This failed to implicate the oviduct as a pathway by which a possible uterine inhibitory factor reached the ovary. (AH h5-8)

The effect of several methods of oviduct blockage on sexual behavior in ewes and cows was investigated. Intensity of estrus tended to be slightly higher in ewes with oviducts blocked with physiological adhesive than in controls; otherwise, there was no appreciable effect of oviduct treatment on overt sexual behavior. The presence of spirals in the uterus shortened estrous cycle length, which was due to inhibition of corpus luteum development. The overt manifestations of sexual behavior during estrus were not markedly different in the "spiral" ewes, although rams tended to detect estrus more slowly in these ewes. Oviducts were removed from 3 cows and their sexual behavior was observed. The intensity of estrus and estrous cycle lengths were normal. (AH h5-8)

The effect of the IUD on endometrial vascular function was studied with rabbits. Plastic spirals were inserted into the lumens of both uterine horns of 10 follicular-phase rabbits. Sham operations were performed on 10 other rabbits. Fifteen days later, 5 rabbits of each group were ovulated with HCG; 9 days after this each rabbit was given an intravenous injection of trypan blue dye and killed 20 minutes later. The mean amounts of dye extracted from endometrial tissue (in micrograms per gram of tissue) were: follicular-phase controls, 615; follicular-phase spiral rabbits, 490; luteal-phase controls, 240; luteal-phase spiral rabbits, 225. The endocrine state of the rabbit influenced endometrial vascular function significantly, but the presence of a spiral in the uterus did not. This differs from swine, where an intra-uterine spiral caused an increase in endometrial vascular permeability in estrous gilts, although it did not do this in luteal-phase gilts. (AH h5-8)



2. Comparative studies of "repeat breeders" and normal cows and heifers. At the Veterinary Institute, Beit Dagan, Israel, clinical studies of 209 heat periods in parous cows showed a length of approximately 20.7 and 19.4 hours for normal cows and repeat breeders, respectively, if standing heats only are considered. These figures are longer than those reported for dairy cattle in other areas with hot climates, but they are similar to observations in temperate climates. No less than 36% of heats were nonstanding. Using a teaser bull halved the incidence of nonstanding and silent heats. Ovulation occurred on an average of 11.9 hours for normal cows and 13.0 hours for repeat breeders, and was influenced by heat checks with a teaser bull. Delayed ovulation and anovulation were of low incidence (1.5% and 4.3%, respectively), but ovulation without heat was frequent (9.5%). Heifers showed shorter estrus (19.4 hours) and earlier ovulation times after estrus (11.5 hours). Marked differences between normal cows and repeat breeders were not found for any of the clinical parameters investigated.

Post-mortem ovum recovery rates were 92% from normal cows and 81% from repeat breeders; 20.6% of the ova were considered abnormal, with frequency in repeat breeders twice that of normal cows. Fertilization rates at 3 days, nonreturns at 3 weeks, and live embryos at 5 weeks post-insemination were as follows: normal cows 83%, 77%, and 69%; repeat breeders 70%, 48%, and 35%. The period of greatest difference in loss between normal cows and repeat breeders was that between 3 days and 3 weeks post-insemination; normal cows had a 6% fertility loss and repeat breeders showed a 23% loss. Infection and inflammation seem to be of negligible importance. (A10-AH-2)

3. Fertility in postpartum cows. At Wisconsin, the interval to first estrus after parturition, the fertility at first service, and the length of the return interval to infertile first service was studied. This experiment was of factorial design involving two genetic levels of production, two levels of concentrate feeding, and two plans of breeding management. Results on first ovulatory heat are available on 145 cows. Among high producers, those fed on high concentrates returned at an average of 42 days, those on medium concentrate, in 36 days. Among the medium-producing cows, those on high concentrates returned at 36 days and those on medium concentrate, at 30 days. Data are available on the fertility at first service for 103 cows. Over the whole experiment, those bred at first heat after calving had a conception rate of 53%, whereas those bred at the first heat following 75 days delay had a 76% rate. Conception rate at first service averaged 64% for the high producers and 66% for the medium producers. Those on high concentrates averaged 64% and those on the medium concentrate, 67%.

If bred at first estrus, the high-producer conception rate was 43% and the medium, 61%. If breeding was delayed until after 75 days, the value for high producers was 79%, and medium producers, 72%. If cows on high concentrates were bred at first heat, the conception rate was 48%; if on medium concentrate, the conception rate was 59%. When cattle on these two

levels of concentrates were delayed in breeding until after 75 days, the averages were 79% for the high concentrate, and 73% for the medium concentrate.

Return intervals from infertile services on animals bred at first heat were outside the normal 18-26 day range in 18 out of 34 cases. For those first bred at heat following 75 days postpartum, they were outside in 3 out of 14 cases. (AH h5-6)

## B. Physiology of Milk Secretion

1. Influence of prior pseudopregnancy on lactation and reproduction of rats. Conflicting opinions exist regarding the effect of parity on milk yield. The cumulative effect of successive pregnancies is difficult to distinguish from other effects accompanying advancing age, increases in body size or digestive capacity.

Pseudopregnancy in the rat, produced by mating with vasectomized males, causes a 10-12 day stimulation of the mammary gland similar to early pregnancy. To study the effect of prior mammary stimulation, rats were compared that had (a) two prior pseudopregnancies, (b) one prior pseudopregnancy, and (c) no previous mammary stimulation. These rats, of equal age, were then bred to intact males and their reproductive and milk producing performance determined.

Rats stimulated by 2 pseudopregnancies (a) had slightly better reproductive performance (15-18% increase in litter size and weight) than those on treatments (b) and (c). All litters were standardized at birth to 10 young and weighed periodically to determine lactational performance of the dam. Growth of the litters, number surviving, and dam weight at weaning were similar for all groups. This experiment thus indicates that the prior mammary stimulation afforded by pseudopregnancy did not increase milk production. (AH g3-8)

2. The mechanism of lactation and its augmentation by hypothalamic stimulation. Previous work on the interrelationships of the hypothalamus and the anterior pituitary gland led to the formulation of a working hypothesis for the mechanism of lactation. Depression of the hypothalamus with tranquilizers results in a release of a prolactin releasing factor (PRF), the consequent release of prolactin from the pituitary, and lactation in the mammary gland. The lack of a sensitive and easily reproducible method for prolactin evaluation has hampered research, and a considerable portion of this year's work was devoted to a study of prolactin assay methods. Four approaches were studied for prolactin assay on the pigeon crop gland: cell culture, organ culture, DNA content after in vivo injection of prolactin, and  $P^{32}$  uptake. While all methods responded well to prolactin, they did not allow a quantitative determination. The rat mammary gland was then tested for its utility in



prolactin assay. An organ culture method appears promising since it is sensitive to 0.001 I.U. prolactin per ml. of medium.

Estradiol was found to be a strong stimulator of prolactin release in pituitary culture experiments in vitro and its effect on milk yield in lactating rats was therefore tested. Milk yield, measured on days 14, 16, 18, and 20 of lactation, indicated that small dosages of estradiol stimulated milk secretion while higher dosages were inhibitory.

Hypothalamic homogenates were made to extract the PRF. Extraction at different pH showed that the largest yield was obtained by extraction with N/10 acetic acid. The PRF content of the hypothalamus increased from the second day postpartum to a maximum on the seventh day and disappeared with weaning of the litter on the 21st day postpartum. (A10-AH-3)

### C. Environmental Physiology

1. Effect of heat stress on digestibility and water utilization of lactating Holstein cows. Twelve cows were used to evaluate the efficiency of utilization of energy and changes in water balance when fed high levels of fat under environmental temperature conditions of 15-20°C and 32°C. The cows were fed 0.57 kg. of alfalfa hay per 45 kg. of body weight and a concentrate without added fat or with 10% saturated or unsaturated vegetable fat added to the concentrate. There was no clear evidence that the cows receiving energy in the more concentrated form as fat showed any marked difference in response to the thermal stress; however, cows on the unsaturated vegetable fat had higher milk yields than cows on the control rations or that fortified with oil. The high temperature increased body temperature 1°C and respiratory rate and volume 130-143%. Under thermal stress (32°C) the therms of estimated net energy consumed declined 14% the first week and 21% by the second week. Correspondingly, yields of milk energy output declined 28-38% and there were small losses in body weight. Although feed energy intake was depressed, the level remained 20% or more above the estimated needs for body maintenance and production. At 32°C water consumption increased 40% during the first week but declined slightly the second week. At the temperatures of 20°C and 32°C, corresponding values were 52 and 114% for rate of sweating, 6 and 46% for respiratory vaporization, and 14 and 40% for urine volume. At the higher temperature, the water content of the feces declined 33%. These results show that: (1) body maintenance requirements are significantly increased when respiration rate exceeds 125 per minute, a condition which often happens during the summer; (2) increased water intake does not impair energy digestibility or accelerate rate of passage; and (3) cattle can utilize large volumes of water for convective cooling without causing serious changes in electrolyte balance. (AH g4-1)

2. The effect of thymectomy on growth and antibody production, and on development of the thyroid, spleen and lymph nodes of calves.

Growth rate and antibody response of 12 thymectomized Holstein male calves have been compared to normal pairmates. The thymus glands were removed 24-48 hours after birth and sham operations were performed on the pairmates. The findings to date show that growth rate is not influenced by thymectomy but production of antibodies is impaired; therefore, as with other species, the functioning of the thymus gland may be important in viability and the early stages of calfhood development. (AH g4-1)

3. Estimating changes in water dissipation in the cow. To explore the extent and variation among animals and the possible genetic relationship of physiological stress conditions, a system has been developed to determine the total body surface and respiratory evaporation rate and changes in CO<sup>2</sup> combining power of the blood simultaneously. The apparatus affords the advantages of simultaneous measurements and markedly reducing time and manpower requirements. Also, it will permit testing of larger numbers of animals for the relationship of these traits to the adaptability of cattle to thermal stress. (AH g4-1)

4. Effect of endo- and ecto-parasite control on growth rate and adaptation to heat stress. At Pirassununga, Brazil, a group of heifers sprayed or treated with anti-helminthic medicine at 20-day intervals for the control of ticks, grubs (Dermatobia) and internal parasites was compared for growth rate and resistance to heat stress to a group without vector control measures. The duration of the test was 12 months. The treated group made significantly higher weight gains, better efficiency of feed utilization, and showed less response to thermal stress; but there was no significant difference in the number of red cells, hematocrit or hemoglobin. Feed consumed per kg. of gain was 28% higher for the untreated group. The untreated group failed to shed their winter hair coats and, even after removing the heavy hair coat by clipping, they showed poorer resistance to heat stress. At the end of the 12-month period, most of the untreated group showed complement fixation titers, indicating some degree of infection to anaplasmosis. Most of this group also had high fecal egg counts. It is concluded that an effective parasite control program is important in efficiency of feed utilization and to the ability of the young animal to become adapted to the stress of hot climates. (S3-AH-7)

5. Relationship of breed and age to hair coat length and density. Monthly observations of length of hair coat and follicle density were made on 3-5 year old Brown Swiss, Holsteins, Jerseys, Zebus, Zebu-European crosses, and Criollo for 3 years at Pirassununga, Brazil. Age had a significant effect on follicle density but not on length of summer and winter hair coats. Breed and season effects were important in both density and length. The pure Zebu had the greatest follicle density but shortest coat, except for the Criollo. The density was about the same for the Criollo and European groups but the coat of the Criollo was always the shortest. In the European breeds, the among cow variance for length of



both summer and winter coat was important. In these breeds, there was also a significant negative correlation (-.37) between length of summer hair coat and milk yield. These results show wide variation in the characteristic hair coat of temperate and tropical origin breeds, even when reared under subtropical conditions. The data also indicate Holsteins with predominately black coloring are best suited to conditions in Brazil. (S3-AH-7)

6. Growth and age of first estrus in three breeds of Indian cattle. Studies of growth rate and age of first estrus were made on three Indian breeds--Red Sindhi, Sahiwal, and Tharparkar--at the National Dairy Research Institute, Karnal, India. Even under high levels of feeding the Indian breeds seemed to develop at a slower rate than is considered characteristic of dairy breeds in temperate climates. Although the Red Sindhis were somewhat smaller than the other two breeds, there were no significant differences among breeds in rate of growth. The average age at first observed estrus was 24-26 months, at an average body weight of 640 pounds. Periodic palpation of the ovaries indicated no follicular development until 21 months or later. Studies of rectal temperature, respiration and pulse rate, and certain blood constituents showed that although there were seasonal fluctuations, the animals were not under severe enough stress to impair ovarian activity. From these results it seems likely that genetic causes account for the reported slow rate of sexual maturity, characteristic of Indian breeds. (A7-AH-6)

7. Studies of the sweating rate of Indian cattle and buffaloes. At the Indian Veterinary Research Institute, it was found that under 65°F temperature conditions the rates of water vaporization from the skin were similar for two breeds of cattle and one breed of buffalo. But under both hot-dry and hot-humid conditions, there was a marked rise in all groups with the cattle averaging 30% more. Wetting the animals with water after 3 hours exposure to hot conditions caused a marked decline in the surface vaporization rate of buffaloes for up to 3 hours, but only 1/2 to 1 hour in cattle.

Studies of the effects of certain adrenergic and chlorenergic drugs on sweating rate showed that at 65°F, local skin injections of philocarpine, acetylcholine, distilled water, and normal saline solution did not make any change in the rate of skin vaporization, but adrenaline caused a 5-fold increase. Under hot-humid conditions, acetylcholine and adrenaline showed some sudorific effect. Atropine alone appeared to have no effect on sweating rate, but when atropine injections were superimposed on a skin area treated with acetylcholine under hot-humid conditions, the sweating rate was reduced 52%.

These results support the hypothesis that sweating in cattle is controlled by adrenergic nerves and although adrenaline is a potent sudorific agent, the adreno-medullary secretion is not implicated in heat-induced sweating. (A7-AH-1)

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Physiology of Reproduction

- Ginther, O. J., Pope, A. L., and Casida, L. E. 1966. Local effect of an intra-uterine plastic coil on the corpus luteum of the ewe. J. Animal Sci. 25:472-475. (AH h5-6)
- Hawk, H. W. 1965. Inhibition of ovum fertilization in the ewe by intra-uterine plastic spirals. J. Reprod. Fertil. 10:267-269. (AH h5-8)
- Hawk, H. W. 1966. Some effects of plastic spirals in sheep uteri. J. Animal Sci. 25:924 (Abs.). (AH h5-8)
- Lynn, J. E., Collins, W. E., Inskeep, E. K., McShan, W. H., and Casida, L. E. 1965. Effects of gonadotropins, oxytocin and glucose on the bovine corpus luteum at the fourteenth day of the estrual cycle. J. Animal Sci. 24:790-794. (AH h5-6)
- Reisen, J. W., Saiduddin, S., Graves, W. E., Tyler, W. J., and Casida, L. E. 1966. Pituitary prolactin activity in postpartum dairy cows. J. Animal Sci. 25:929 (Abs.). (AH h5-6)
- Saiduddin, S., Reisen, J. W., Graves, W. E., Tyler, W. J., and Casida, L. E. 1966. Pituitary LH activity in the postpartum dairy cow. J. Animal Sci. 25:930 (Abs.). (AH h5-6)
- Stormshak, F., and Hawk, H. W. 1966. Effect of intra-uterine spirals and HCG on the corpus luteum of the ewe. J. Animal Sci. 25:931 (Abs.). (AH h5-8)

Physiology of Milk Secretion

- Ben-David, M., Dikstein, S., and Sulman, F. G. 1966. Role of the thyroid in hypothalamic lactation. Proc. Soc. Exp. Biol. Med. 121:873-876. (A10-AH-3)
- Bitman, Joel. 1965. Determinations of lactose in mammary gland and in milk. J. Dairy Sci. 48:1396-1398. (AH g3-8)
- Cecil, H. C., Bitman, J., and Wood, J. R. 1965. Changes in milk glycogen during mastitis. J. Dairy Sci. 48:1607-1611. (AH g3-8)
- Dikstein, S., Ben-David, M., and Sulman, F. G. 1965. Provisional Patent Application to United Kingdom No. 664/65. Filed January 7, 1965. Production of lactation by non-sedative phenothenzine derivatives. (A10-AH-3)



Mishkinsky, J., Lajtos, Z. K., and Sulman, F. G. 1966. Initiation of lactation by hypothalamic implantation of perphenazine. Endocrinology 78:919-922. (A10-AH-3)

Wrenn, T. R., DeLauder, W. R., and Bitman, Joel. 1965. Rat mammary gland composition during pregnancy and lactation. J. Dairy Sci. 48:1517-1521. (AH g3-8)

Wrenn, T. R., DeLauder, W. R., Wood, J. R., and Bitman, J. 1966. Parity, pseudopregnancy and production. J. Dairy Sci. 49:742. (AH g3-8)

#### Environmental Physiology

Barnobe, R. C. 1966. Hair coat thickness and milk production in Jersey cows. Ph.D. Thesis Vet. School, University Sao Paulo, Sao Paulo, Brazil. (S3-AH-7)

Guidry, A. J. and McDowell, R. E. 1966. Tympanic membrane temperature for indicating rapid changes in body temperature. J. Dairy Sci. 49:74-77. (AH g4-1)

Guidry, A. J., McDowell, R. E., Coleman, G. L., and Crandall, M. L. 1965. The effect of thymectomy on growth and antibody production of calves. J. Dairy Sci. 48:1560 (Abs.). (AH g4-1)

McDowell, R. E. 1966. The role of physiology in animal production for tropical and sub-tropical areas. World Rev. An. Prod. 1:39-50. (AH g4-1)

McDowell, R. E. 1965. Methods of ameliorating adverse effects on physiological function of animals. Proc. 132nd AAAS Meetings, Dec. 27-31, Berkeley, California. (AH g4-1)

Veiga, J. S., Barnobe, R. C., Ghion, E., and Aggio, C. A. C. 1964. Some physiological characteristics associated with adaptability of cattle in tropical and sub-tropical areas. II. Hair coat thickness, hair weight and heat tolerance of cattle. Arq. Esc. Vet. 16:113-137. (S3-AH-7)

Veiga, J. S. 1963. Some physiological characteristics associated with adaptability of cattle in tropical and sub-tropical areas. I. Blood values. Arq. Esc. Vet. 16:167-204. (S3-AH-7)

Related Publications of State Experiment Stations

- Anderson, L. L. Bowerman, A. H. and Melampy, R. M. 1965. Oxytocin on Ovarian Function in Cycling and Hysterectomized Heifers.  
J. Anim. Sci. 24:964-968 Iowa
- Bauman, T. R. and Turner, C. W. 1965. The Oral Effectiveness of L-Thyroxine, L-Triiodothyronine and Thyroprotein as Compared to Injections of L-Thyroxine and Thyroprotein.  
J. Dairy Sci. 48:1353 Mo.
- Bauman, T. R., Hindery, G. A. and Turner, C. W. 1965. Resumption of TSH Secretion as Shown by <sup>131</sup>I Uptake in Cattle After Graded Withdrawal of Thyroxine.  
J. Dairy Sci. 48:484 Mo.
- Becker, R. B., Arnold, P. T. D., Wilcox, C. J., Krienke, W. A., Mull, L. E. and Fouts, E. L. 1965. Subnormal Milk-Cause and Correction.  
Fla. Expt. Sta. Bul. 692 Fla.
- Black, D. L. and Duby, R. T. 1965. Effect of Oxytocin, Epinephrine and Atropine on the Oestrous Cycle of the Cow.  
J. Reprod. & Fertil. 9:3-8 Mass.
- Boyd, L. J. and Hafs, H. D. 1965. Body Size of Calves from Holstein Dams and Sired by Holstein or Angus Bulls.  
J. Dairy Sci. 48:1236 Mich.
- Caruolo, E. V., Mochrie, R. D. 1965. A Program for Efficient and Complete Removal of Milk.  
J. Dairy Sci. 48:830 N.C.
- Cupps, P. T. and Briggs, J. R. 1965. Changes in the Epididymis Associated with Morphological Changes in the Spermatozoa.  
J. Dairy Sci. 48:1241-1244 Calif.
- Donaldson, L. E. and Hansel, William. 1965. Prolongation of Life Span of the Bovine Corpus Luteum by Single Injections of Bovine Luteinizing Hormone.  
J. Dairy Sci. 48:903-904 N.Y.



- Fosgate, O. T. and Hegde, K. S. 1965. Response of Young Holstein-Friesian Heifers to Phenothiazine and Diethylstilbestrol.  
J. Dairy Sci. 48:243-245 Ga.
- Hindery, G. A. and Turner, C. W. 1965. Effect of Administration of L-Thyroxine 25-50% Above Secretion Rate on Lactating Cows.  
J. Dairy Sci. 48:596 Mo.
- Johnson, K. R. 1965. Cyclic Histological Changes Occurring in the Endometrium of the Bovine.  
Idaho Agr. Expt. Sta. Res. Bul. 63 Idaho
- Jorgensen, N. A. and Schultz, L. H. 1965. Ration Effects on Rumen Acids, Ketogenesis, and Milk Composition. II. Restricted Roughage Feeding.  
J. Dairy Sci. 48:1040 Wisc.
- Jorgensen, N. A., Schultz, L. H. and Barr, G. R. 1965. Factors Influencing Milk Fat Depression on Rations High in Concentrates.  
J. Dairy Sci. 48:1031 Wisc.
- Natzke, R. P., Schultz, L. H., Barr, G. R. and Holtmann, W. B. 1965. Variation in Mastitis Screening Tests and Milk Composition of Udder Quarter Samples under Normal Conditions and Following Omission of a Milking.  
J. Dairy Sci. 48:1295 Wisc.
- Pickett, B. W., Hall, R. C., Jr., Lucas, J. J. and Gibson, E. W. 1965. Investigations on Thawing Frozen Bovine Spermatozoa.  
Fertil. & Steril. 16:642 Conn.
- Roussel, J. D. and Stallcup, O. T. 1965. Enumeration of Bovine Spermatozoa by Packed Cell Method.  
J. Dairy Sci. 48:515-516 Ark.
- Turner, G. D. and Williams, W. F. 1965. The In Vitro Incorporation of Progesterone Into Uterine Tissue.  
J. Dairy Sci. 48:789 Md.
- VanDemark, N. L., Koyama, K. and Lodge, J. R. 1965. Factors Affecting Immobilization of Bovine Spermatozoa with CO<sub>2</sub> and their Subsequent Reactivation.  
J. Dairy Sci. 48:568-591 Ill.

## AREA NO. 7: DAIRY CATTLE - NUTRITION

Problem. Information on the nutritional processes and requirements of dairy cattle is needed to obtain a more precise evaluation and a better understanding of feeds and rations as a basis for improving nutrition and feeding practices on farms. Shifts in sources of nutrients fed to dairy cattle require studies on the optimum combination and specific supplements needed in order to provide for the most profitable income over feed cost. Dairymen need to reduce the total cost of feed, improve methods of ration and roughage evaluation, and to better understand optimum combinations for rations. Research results are needed on low quality roughage, synthetic diets and on pesticide residues.

### USDA AND COOPERATIVE PROGRAM

This is a continuing program conducted by biochemists, nutritionists, and dairy husbandmen and is aimed at increasing basic and applied knowledge in the feeding of dairy cattle. Considerable emphasis is placed on basic research. Studies conducted at Beltsville, Maryland, and cooperatively in nine states, focus on energy metabolism through energy balance trials, chemical methods for determining nutritive value of feeds and forage, forage evaluation and utilization, requirements for heifers and cows, and pesticides in tissues and milk.

Cooperative agreements and contracts include the following: \$22,500 annually at Tuskegee, Alabama (fate and metabolism of Diuron in ruminants); \$9,720 annually at Maryland (management, preservation and utilization of grassland crops); \$32,268 annually at Maryland (effects of feeding pesticide treated hay); \$23,581 annually at Michigan (effects of dieldrin residues in young and lactating cows); \$25,000 annually at New York (effect of liberal concentrate feeding); \$16,699 annually at Virginia (effects of the phosphate insecticide, GS-13005, in cows); and, \$20,345 annually at Wisconsin (effect of fungal toxins in forages).

A PL 480 grant for \$17,320 equivalent annually is continuing at Punjab, India, for study of low-grade roughages.

The Federal scientific effort devoted to research in this area totals 11.9 scientific man-years. Of these, 3.8 are in digestion and metabolism, 3.1 in forages evaluation and utilization; 1.3 in factors affecting feed intake, and 3.7 in residues in tissues and milk.

### PROGRAM OF STATE EXPERIMENT STATIONS

The total research effort on dairy cattle nutrition and management by State agricultural experiment stations is 79.0 scientific man-years.



PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Digestion and Metabolism

1. Increased efficiency in conducting energy balance trials with lactating dairy cows. Emphasis has been given to methodology, instrumentation and management during the past year to increase the efficiency of operations in the energy metabolism laboratory at Beltsville. The number of balance trials was increased from 203 in 1964-65 to 254 in 1965-66. This increase is due to the installation of a new data logger system so that data can be collected during a balance trial from more than 2 chambers. Further efficiencies were realized by developing and using computer programs to automatically transfer energy balance data for statistical analysis. (AH h2-8)

2. Energy balance studies with lactating cows. Fourteen potentially high producing Holstein cows were fed combinations of alfalfa hay wafers and corn soybean meal mixture in ratios of 60:40, 40:60, and 20:80. The average yield per cow was 6959 kg. milk and 231 kg. fat. One cow produced 8768 kg. of 4% FCM in 305 days, and exceeded 45 kg. (100 lb.) milk daily at peak production. This is twice the level of daily yield per cow previously reported elsewhere. This cow mobilized 12 to 20 Mcal of body tissue in early lactation while producing 27 to 35 Mcal of milk (80-104 lb. 4% FCM) daily. Even when the cows were allowed to consume rations containing 60 to 80% concentrates in unlimited amounts they were unable to meet their energy requirements during the first few weeks after calving. Although the average loss of tissue during early lactation was 7 Mcal, this varied and was 10.1 for cows receiving 40% concentrates, 7.2 for cows receiving 60% concentrates, and 3.6 for cows receiving 80% concentrates. The early lactation milk yields, listed in the same order of feeding, were 35.6, 29.4, and 19.8 Kg. 4% FCM daily for the three rations fed ad libitum. The average milk fat tests were 4.3, 3.3, and 3.1%. Thus the milk yields of the cows fed high concentrate rations in early lactation were lower than those fed rations containing only 40% of the dry matter as concentrates. This is contrary to what would be expected based on current feeding practices. It appears that the cows on the high concentrate rations were unable to draw from the body fat stores as effectively as those fed only 40% concentrates.

In mid lactation (176 days post calving), cows on each of the three rations consumed the amounts needed to maintain energy equilibrium. The tissue energy balances were 2.3, 1.2, and 0.75 Mcal daily, when fed ad libitum for the rations with 40, 60, and 80% concentrates, respectively. In late lactation (292 days post calving) the mean tissue deposition was 5.2, 7.2, and 8.5 Mcal daily. These data demonstrate that cows are capable of depositing body tissues in late lactation when still producing moderate amounts of milk. The tendency to fatten was greatest when the ration contained high proportions of concentrates, but it occurred even with the 40% concentrate ration.

It has previously been supposed that the efficiency of utilization of metabolizable energy decreases with increased levels of milk production and feeding. A multiple regression analysis of these data indicate a lack of curvilinearity associated with milk yields, suggesting that level of milk production did not significantly influence the utilization of metabolizable energy for milk production. (AH h2-8)

3. Comparative efficiency of utilization of metabolizable energy for lactation and fattening. It is commonly assumed that the efficiency of utilization of metabolizable energy is greater for milk production than for body fat deposition. The factors often quoted are 70% efficiency for milk production and 58% for fattening. These assumptions are based on data obtained when cows were fattening but not lactating. The values have been empirically used to correct for body tissue deposition or loss during lactation. Results from this study do not support these traditionally accepted views. It was found that regardless of level of production, ration, or tissue balance, the efficiency of utilization of metabolizable energy for body tissue deposition (fattening) was equal to, or greater than, the efficiency for milk production when both processes were occurring simultaneously. This, from a practical standpoint, means that conditioning a cow for the next lactation would be more efficiently accomplished during lactation rather than during the dry period; unless the maintenance requirement resulting from a heavier, lactating cow offsets the increased efficiency. (AH h2-8)

4. Maintenance requirements of lactating cows. The maintenance requirements of the cows used in the energy balance trials were approximately 140 kcal ME/kg<sup>3/4</sup>. In previous studies, 116 or 131 kcal ME/kg<sup>3/4</sup> were assumed to be the maintenance requirements for dry and lactating cows. Actual measurements of the maintenance requirements of dry, non-pregnant cows have indicated that it is in the range of 105 to 120 kcal ME/kg<sup>3/4</sup>. Thus, it seems that the maintenance requirements of lactating cows, regardless of the level of milk production, is higher than when the cows are dry and non-pregnant. (AH h2-8)

5. Effect of ration composition on efficiency of utilization of metabolizable energy for milk production. For the rations used in the energy balance trials, where the digestibility ranged from 70 to 77% and the metabolizable energy varied from 60 to 68%, there were no apparent differences in the efficiency of utilization of metabolizable energy for milk production. The metabolizable energy of all rations was utilized with approximately 65 to 70% efficiency for milk production plus tissue deposition. As concentrate levels increased, there were indications of increased efficiency. (AH h2-8)

6. Effects of level of feed intake on digestive losses. In the energy balance trials, the proportion of gross energy lost as feces increased as the level of feed intake was increased. For each increase in intake



equivalent to one times the maintenance requirement, the percentage of energy lost as feces increased by 3.01, 2.38, and 2.16% for rations containing 40, 60, and 80% concentrates. The losses of urine and methane, however, decreased as the level of intake increased. The urine losses decreased by 0.72, 0.97, and 1.26%, respectively, and methane losses decreased by 0.81, 1.52, and 1.68%, per unit increase in intake. These results indicate that increases in level of feed intake affected digestible energy values much more than the metabolizable energy values of the diets. Errors will result from assuming that the ME value of a diet bears a constant relationship to the digestible energy (DE) value of the diet (ME=82% of DE). With the ration containing 40% concentrates the ME comprised 85.15% of the DE. The corresponding values for 60 and 80% concentrates were 87.38 and 88.45%. With all rations, this value increased as the level of feeding was increased.

7. Relation between ruminal volatile fatty acids and milk composition. Samples of rumen contents were routinely collected and analyzed for volatile fatty acids and pH in the energy balance trials. Previous workers have indicated that not only the milk composition but also the efficiency of utilization of metabolizable energy for fattening and milk production are related to the molar proportions of volatile fatty acids in the rumen. The proportion of concentrates to forage in the ration, used in this experiment, affects the proportion of volatile fatty acids and fat test. However, the proportion of volatile fatty acids in the rumen had no effect on efficiency of utilization of metabolizable energy when the concentrates varied from 40 to 80% of the ration. (AH h2-8)

(a) Cell wall constituents. The previously developed method based on neutral detergent for the determination of cell wall constituents in forage crops has been modified and standardized so as to be applicable to all feedstuffs, including concentrates. It has been found that the inclusion of 1% ethoxyethanol in the reagent and a modification in the filtration procedure is effective in overcoming starch interference inherent in the older procedure. The standardization of the method is based on a nutritional concept which defines fiber as insoluble vegetable matter, indigestible by proteolytic and diastatic enzymes, and which cannot be utilized except by microbial fermentation in the digestive tracts of animals. The neutral detergent fiber and the previously developed acid-detergent fiber are presently under study by the Association of Official Analytical Chemists as prospective replacements for the less accurate crude fiber and proximate analysis. (AH h2-6)

(b) Digestibility of cellular contents. In the new methods of analysis, the portion of the feedstuff that is solubilized by the neutral detergent reagent is classified as cellular contents. Results indicate that this fraction is almost completely digestible (98%). From this information, along with the determination of the acid detergent fiber and the lignin content of this fiber, the true digestibility of the feed now can be calculated. (AH h2-6)

(c) Effect of various factors on endogenous excretion in fecal matter. The feces of forage-fed herbivora are known to be composed of endogenous excretions from the animal, bacterial residues, and undigested forage consumed in the ration. It has been shown that the pattern of the endogenous and bacterial residue excretion is different in non-lactating and lactating cows. The excretion varies with the physiological state level of intake and digestibility. At very high levels of intake with lactating cows, the excretion may increase and be partly responsible for previously reported declines in digestibility. The composition of the excretion has been studied and found to be very largely composed of undigested bacterial remnants. For the first time, through the development of these new methods, it is possible to physically separate the endogenous and bacterial residues from the undigested feed residues in fecal dry matter. The newly developed methods show considerable promise in throwing new light on the digestion processes taking place in ruminants. (AH h2-6)

(d) Lignin content of fecal cell walls. Questions have been raised concerning the digestibility of forage particles as affected by its size. The cell wall method has been applied to the preparation of quantities of fecal cell walls for particle separation studies. Preliminary results show that the larger particles have a much lower lignin content than do the fine particles. This indicates a considerable difference in the extent of digestion of different sized particles. Apparently the bacteria of the rumen attack and digest out the hemicelluloses and celluloses more rapidly in the fine particles. (AH h2-6)

(e) Modification of in vitro Tilley digestion technic. Many in vitro methods have been proposed to determine the digestibility of forages. In vitro digestion was carried out according to the Tilley and Terry procedure "D" which includes two stages: a 48-hour in vitro rumen bacterial fermentation followed by a 48-hour acid pepsin digestion. In the modification the acid pepsin stage was replaced by a cell-wall determination using the neutral detergent procedure. Results from the in vitro digestion, followed by determination of undigested cell-wall material, yielded digestibilities greater than those obtained by the Tilley procedure. While the values obtained through in vitro digestibility by the cell wall procedure are higher than corresponding apparent digestibility in vivo, it appears that the in vitro procedure based on cell walls is superior to the Tilley method for estimation of both true and apparent digestibilities. The correlation coefficient between in vivo apparent digestibility in the original Tilley procedure was 0.93, while that for the modified procedure was 0.96. This new in vitro procedure is also shorter by two days and requires fewer laboratory manipulations. It is concluded that this in vitro procedure will be of aid to agronomists and nutritionists who may not wish to rely entirely on the results of chemical composition. (AH h2-6)



## B. Forage Evaluation and Utilization

1. The value of mature corn for silage. Since late harvest of corn forage can be advantageous to work schedules and availability of silo space, experiments were conducted with gas-tight silos to determine the effect on feeding value and nutrient loss when harvest was delayed beyond full plant maturity. A 50-60 day delay in harvest resulted in a reduction in dry matter yield per acre of 19% and 27% in two successive years. Feeding trial results indicate no effect of delayed harvest on silage dry matter consumption, milk production, or changes in bodyweight. It appears that a prolonged delay in harvest must be considered unsatisfactory as a general practice because of the large field losses. However, the satisfactory levels of preservation (in excellent silos) and utilization by the dairy cow would justify delayed harvesting when such delays are unavoidable. (AH h3-3)

2. The relative value of bunker and gas-tight silos. Previous research demonstrated that unfavorable weather may prolong the storing of low moisture silage in bunker silos and result in low preservation efficiency. By largely eliminating delays and storing orchardgrass in both a bunker and Harvestore silo at about 70% moisture rather than 50%, filling delays were largely eliminated and dry matter preservation was greatly improved to about 93% in the Harvestore and 91% in the bunker. Dry matter intake of bunker silage was significantly greater even though the chemical quality and intake of both silages was poor relative to that experienced with lower moisture material. However, milk production and bodyweight gains were adequate for both feeds but again were greater for the bunker silage. It is concluded that the ensiling of orchardgrass forage in bunker silos may result in preservation efficiency and silage feeding value equal to that noted in Harvestore silos, providing proper filling and sealing procedures are used. It is also concluded that bunker filling should be as rapid as possible, even though it may result in a higher moisture content than was originally intended. (AH h3-3)

3. The effect of mechanically removing plant moisture prior to ensiling. The beneficial effects of reducing plant moisture by wilting in the field prior to ensiling have been well documented. This experiment was initiated to compare direct-cut, low-moisture and dewatered alfalfa silage. The mechanical dewatering process in the field resulted in a juice loss in the field of 8.8% of the crop dry matter, with 40% of the lost dry matter in the form of crude protein. Total ensiling losses for the direct-cut, low-moisture, and dewatered forage were 23.1%, 5.0%, and 13.1% of the stored dry matter, respectively. All three silages were of equal value with respect to milk production, even though greater dry matter intakes were observed from low moisture silage. The large and quite similar total crop dry matter losses associated with the direct cut and dewatered processes preclude the employment of either method over the wilting procedure. (AH h3-3)

4. The importance of fineness of chop on low moisture silage preservation. The general recommendations for the proper harvesting and storage of low moisture forage include chopping the material as fine as possible. Two silos were filled simultaneously with first cutting low moisture orchardgrass-alfalfa mixture, using two forage harvesters set at 1/4 and 3/4 inch theoretical length of cut. The dry matter bulk density at the completion of filling, and again after 180 days of setting, was only about 5% greater for the short chop material. When expressed as a percent of that stored, the distribution of the dry matter recovered, for the short and long chop, respectively were: good silage, 96.3% and 91.1%; spoilage 4.3% and 6.7%; invisible loss -0.6% and 2.2%. Values for pH, ammoniacal nitrogen and organic acids were similar between silages, and indicative of the limited fermentation one would expect from the storage of 45% dry matter forage. The data from this experiment indicate that reducing the length of chop of low moisture forage in well managed silos has little value in increasing the capacity of upright silos and in chemical quality of silage. It is of value in reducing total storage losses. (AH h3-3)

5. Oat silage as affected by stage of maturity and ensiling method. Researchers at several other stations recommend direct-cut harvesting in the late boot to pre-bloom stage and the addition of 10% ground grain at time of storage in the ensiling of small grain forages. Studies at Beltsville were made to determine the possible benefit of wilting this type of forage as an alternative to adding grain. Although adding corn meal consistently increased digestibility, voluntary intake of dry matter, including digestible dry matter, was highest on the less digestible early cut wilted oats. It was concluded that a significantly greater intake may be derived from wilting boot stage winter oats as opposed to direct cutting and adding 10% corn meal. Intake from both treatments were about equal at a later (soft dough) stage of cutting. Apparently at an early stage of maturity or at high levels of digestibility some silage characteristics related to low moisture may influence intake more than digestibility. (AH h3-3)

6. Measurement of field losses in wilted forages. The net advantage of storing forage crops as wilted or low-moisture silage depends to a large extent on the magnitude of any increase in field losses associated with the wilting and harvesting. For this study, forage harvested by direct cutting was considered as the initial maximum value rather than the measurement of the standing crop before harvest. Small parallel plots were harvested in a number of ways with conventional field machinery. The entire plot yield was collected, weighed, and samples in a special wagon. When alfalfa was mowed, conditioned, and windrowed in one operation with a self-propelled machine and wilted without rain damage, average harvesting losses were 3.4% or less. Rain damage increased average losses to 12% in similarly handled forage. However, when alfalfa was mowed and raked into windrows in separate operations, harvesting losses averaged 10-17% even during good weather. It was also observed that slow drying and leaching



under sprinklers produced only minor dry matter losses when mechanical damage and shattering were eliminated. These results indicate that the raking and reraking involved with usual field wilting is the major source of field losses. Elimination of raking by combined mowing and windrowing will appreciably reduce losses, in spite of longer field exposure periods. (AH h3-3)

7. Effects of aeration and pre-wilting on silage quality. Third cutting alfalfa was chopped without wilting and spread on a concrete slab. Samples were removed at various time intervals to provide forage with varying degrees of wilting. Four quart jars were filled with forage from each lot and subjected to one of four rates of continuous aeration for 30 days. Chemical analyses of the silages showed that pH and ammonia levels were increased by increasing the extent of aeration. However, this effect was related to the moisture content of the forages. The lower dry matter material gave a greater response to aeration in terms of ammonia nitrogen. This suggests that a given rate of aeration may be more damaging to higher moisture silage. (AH h3-3)

8. Feeding value of Lindsey 77F hay. Lindsey 77F, a grain sorghum is a promising forage for some areas in the south. Hays made from Lindsey 77F, alfalfa and red clover were compared as the only forage and fed to 18 milking Jersey cows at Lewisburg, Tennessee. There was a significant difference in the pounds of hay consumed per cow per day, with the means being 17.3 lbs. for alfalfa, 16.9 for Lindsey 77F, and 16.0 for red clover. There were no differences in the production of 4% FCM, or gain or loss in body weight. Thus Lindsey 77F hay, properly cured, appears to be a good forage source for dairy cattle. (AH h3-12)

9. Low moisture alfalfa-orchardgrass, RS 610 grain sorghum and corn as silages for dairy cows. Low moisture alfalfa silage was made from the first cutting at Lewisburg, Tennessee. The corn used as silage had a yield of 18.5 tons and the RS 610 grain sorghum 13 tons per acre on a 30% dry matter basis. The grain yield per acre was 85 bu. from corn and 103 bu. from grain sorghum. Forage dry matter consumption per 100 lbs. body weight for the alfalfa, corn, and sorghum silages was 2.55, 2.08, and 1.94, respectively. In the same order 4% FCM production was 39.7, 38.1, and 39.4 lbs. per day. The alfalfa and RS 610 grain sorghum silages were significantly superior to the corn silage for milk production in Jersey cows. (AH h3-12)

10. Stored forage compared to pasture plus supplemental stored forage for milk production. At Lewisburg, Tennessee, 8 two-acre plots seeded to a mixture of alfalfa, orchardgrass and Ladino clover were harvested by two management systems. Four plots were grazed in rotation by lactating Jersey cows, and four plots were harvested as wilted silage and fed in dry lot to their pair mates. Spring growth in excess of pasture needs was harvested as silage and credited to the pasture plots. Six years'

data show that the stand of alfalfa, orchardgrass and Ladino clover produced 32% more milk per acre when harvested and fed as silage than when the same crop was grazed in rotation. Alfalfa and Ladino clover remained in the stand better in the harvested plots than in the plots that were grazed. Even though milk production per day was consistently higher for cows on pasture (40.7 vs. 38.5 lbs. per cow/day), there appears to be a considerable advantage of harvesting over grazing in terms of total production and persistence of the stand. (AH h3-12)

### C. Factors Affecting Feed Intake

1. Formic acid silage compared to hay for growth. Previous experiments have shown a reduced rate of growth when heifers are fed unwilted silage as compared to hay from the same source fed as the sole ration. The reduced growth is primarily a result of a lower energy intake. Studies at Beltsville have been made to determine if formic acid, when added to silage, will aid in preventing the development of undesirable fermentation products and if it will aid in increasing acceptability by heifers. Orchardgrass was harvested as barn dried hay and as direct cut silage treated with 0.5% by weight of 90% formic acid added as undiluted acid at the blower. The equal if not greater growth of silage-fed animals compared to hay fed animals is in sharp contrast to previous hay versus unwilted silage results. This result occurred despite the lower dry-matter intake for the animals fed silage treated with formic acid. In digestibility trials, it was found that when the animals were fed at a maintenance level, the digestibility of the dry matter was 67.6% for the hay and 74.6% for the silage. When fed on an ad libitum basis the corresponding digestibilities were 65.4 and 73.7. The increase in digestibility appeared to take place in the cellulose, protein and solubles fractions and amounts to an increase of 33% in digestible energy per unit weight of feed dry matter. If these preliminary results are substantiated, extensive benefits can be realized in the greater utilization of energy from harvested forages. (AH h1-1)

2. Rumen factors affecting intake of silage and hay. An analysis of three years of data showed that heifers consuming hay had a total wet weight of the rumen contents of 12.9% of body weight compared to 11.7% when fed silage on an ad libitum basis. The total weight of the dry rumen content was 1.85% and 1.51% of body weight for hay and silage, respectively. The rumen retention time was 1.25 days and 1.19 respectively at the restricted level of feeding. These results indicate that the total fill in the rumen does not limit silage intake, and that there is no tendency for silage residues to remain in the rumen longer than hay residues. These results clearly demonstrate that the lower intake of dry matter in silage vs. hay is not a function of rumen fill or retention time, as had been previously suggested. (AH h1-1)

3. Determination of the gross energy value of silage. In conducting feeding trials, digestibility studies and energy balance trials with



silages, the method of determination of the gross energy value of a given sample of silage is critical and errors can result in a misinterpretation of results. The difficulty in silages is caused by the presence of volatile nutrients in the silage in the form of folatile fatty acids and volatile nitrogen compounds. The determination of the gross energy value, using a bomb calorimeter, is in error if the silage sample is dried in an oven or freeze dried because of volatilization of some of the nutrients. Results at Beltsville support the view that the gross energy values for silage can be obtained only by burning in the wet state, using a primer such as dimethylformamide in the bomb calorimeter. (AH hl-1)

4. Effect of feed particle size on intake, rumen retention time and digestibility. In order to develop a better understanding of the effect of forage preparation on certain physiological responses, orchard-grass was fed as (1) ground through a 3/8 inch screen and made into 1/4 inch pellets, (2) rolled wafers 2 1/4 inches in diameter and 4 1/4 inches long, and (3) chopped. The dry matter intake of pellets was 2.24% of body weight, compared to 1.5% for the wafers and 1.66% for the chopped hay. No significant differences were observed in total weight of rumen dry matter, when expressed as a percentage of body weight. The rumen retention time of the pellet dry matter was 0.94 days, 1.49 for wafers and 1.37 for chopped hay. It was concluded that (1) a greater fiber digestion and lower digestion of protein occurred with increased size of the feed particles, (2) particle size influenced retention time in the rumen as well as amount of intake, (3) particle size may be more important than previously thought since there were differences between the rolled wafers and chopped hay and (4) chopped hay having a finer particle size than the wafers had greater intake and shorter retention time. (AH hl-1)

5. Effect of non-protein nitrogen on feed intake. When non-protein nitrogen compounds such as urea are added to rations at high levels, a reduction in feed intake results. The mechanism by which the feed intake is reduced is not completely understood. It has been suggested that the effect may be due to reduced palatability of the ration containing the compound, a high level of ammonia in the rumen, or a high level of blood ammonia. Four fistulated Holstein heifers were fed varying levels of urea mixed in feed. Eighty to 90% of the feed intake variation was accounted for by level of urea intake, rumen ammonia levels, and blood ammonia levels. However, there was a higher correlation between blood ammonia levels and feed intake when the urea was infused into the rumen than when the urea was mixed with the feed. While further analysis and interpretation of these results are needed, one theory concerns a control mechanism which maintains very low levels of blood ammonia. When this level in the blood is excluded, a reduction in feed intake results. (AH hl-1)

At Punjab, India, a study was made on the effect of frequency of feeding rations containing urea and wheat straw. Zebu cattle and water buffalo were fed wheat straw ad libitum and a concentrate mixture consisting of wheat bran and peanut cake in which 30% of the nitrogen was urea. The

voluntary intake of dry matter was significantly higher in four times vs. twice a day feeding. Corresponding values were 3.82 and 3.92/day for acetic-propionic acid ratios, 20.0 and 17.8 meq/l for ammonia content of the rumen, and 0.33 and 0.24 Kg./day for rate of gain. Concentrations of total volatile fatty acids, acetic and propionic acid in the rumen fluids was higher in buffalo than in Zebu heifers. Acetic-propionic acid ratios were similar for the two species. (A7-AH-11)

6. Non-protein nitrogen utilization. Attempts are being made to uncover non-protein nitrogen compounds which will permit the slow release of ammonia in the rumen. Urea is the most common non-protein nitrogen compound used as a substitute for high protein feeds. Preliminary studies on a clathrate of urea have been conducted. Results show that the rate of ammonia release in the rumen was slower for the clathrate than urea. Also the clathrate did not depress intake of dry matter any more than urea. While the new compound shows possibilities for practical use, studies must be conducted on its effect on nitrogen balance and growth of animals. (AH hl-1)

Cooperative work on the effect of adding urea to a low protein ration was conducted at Punjab, India. Urea was added to a basal ration supplying 70% of Morrison's requirement of protein. Results indicated that the addition of urea to low protein rations increased digestibility and disappearance of the feed residues from the digestive tract. This resulted in an increased voluntary intake of dry matter. (A7-AH-11)

7. Effect of ration composition on carotene utilization. Last year it was reported that the carotene of corn silage was utilized as efficiently as the carotene from dehydrated alfalfa leaf meal, using a basal ration of a concentrate mixture fed ad libitum, plus one pound of skimmilk powder per day. However, when the skimmilk powder was omitted from the ration of two calves, the corn silage carotene was not efficiently utilized. In further work during this year when skimmilk powder was omitted from the basal ration, it was demonstrated that the carotene from dehydrated alfalfa meal was also not efficiently utilized. Blood plasma vitamin A and carotene as well as spinal fluid pressure were used as criteria of adequacy of carotene intake. These results suggest a less efficient conversion of carotene to vitamin A in the intestinal mucosa, and that some nutrient in skimmilk powder affects the utilization of carotene in the ration. (AH hl-5)

8. Comparative rate of passage of feed residues in buffalo and Zebu cattle. In a trial using green alfalfa and wheat straw at Punjab, India, the 5% retention time and the mean retention time in the rumen was 26 and 64 hours for the buffalo vs. 31 and 78 hours for Zebu cattle. Voluntary intake was similar for the two species. Digestibility coefficients for dry matter, crude fiber and crude protein were only slightly higher for the buffalo. It appeared that other factors such as movement of the walls and pillars of the reticulo-rumen, size of the reticulo-omasal orifice,



duration and efficiency of rumination, and gut contents may be responsible for the faster rate of passage of feed residues in the buffalo. (A7-AH-11)

D. Pesticides in tissues and milk.

1. Imidan at Tifton, Georgia. An emulsifiable concentrate of Imidan was sprayed onto a corn crop at the rates of 8, 16, and 32 oz. per acre. The forage from each of the treated plots and a control plot was harvested as silage 24 hours later and stored in separate silos. After six weeks' storage the silage was fed ad libitum to four groups of lactating dairy cows for eight weeks. Prior to ensiling, the residue disappeared rapidly from the corn plants. After ensiling the loss of Imidan from the silage was slow -- about 50% loss in 92 days. Milk samples taken at weekly intervals for eight weeks failed to show any Imidan in the milk of the cows fed silage made from corn treated with 32 oz. per acre. Blood samples collected at weekly intervals during the feeding of Imidan contaminated silage showed no cholinesterase inhibition from those fed the corn treated with 8 and 16 oz. per acre. There was approximately a 20% decrease in cholinesterase inhibition in blood samples collected from animals fed silage made from corn treated with 32 oz. of Imidan per acre. (AH h2-14)

2. Imidan in relation to reproduction. In the previous experiment at Tifton, Georgia, the feeding of corn silage containing several levels of Imidan residue was associated with abortions in three of sixteen milking cows during an eight week feeding period. To verify this possible relationship, corn forage at Beltsville was sprayed with Imidan 3-E at 1.0 and 3.0 pounds per acre, ensiled in ground stacks, and fed for 50 days to two groups of three Jersey cows in their 3-6 month of gestation. Daily Imidan residue intakes amounted to 161 and 214 mg. or .33 and .42 mg./kg. bodyweight for the respective treatment levels. This was considerably greater than the 114 mg. daily intake on the highest level at Tifton. There was no apparent depression in erythrocyte cholinesterase activity on either treatment during the feeding period. All animals were diagnosed as pregnant at the end of the feeding trial and again fifty days later. It was concluded that no relationship existed between consumption of corn silage containing relatively high levels of Imidan residues and abortion. (AH h2-14)

3. Toxicity and excretion in milk of Dimethoate and its oxygen analog. In previous work conducted at Tifton and Beltsville it was shown that forages sprayed with as much as 2.0 pounds of Dimethoate per acre resulted in some residues in silage. When the silage was fed no Dimethoate was found in the milk and no inhibition of blood cholinesterase activity occurred. Since these data were obtained the occurrence of the oxygen analog of Dimethoate as a residue has been shown to be a possibility. A combination of pure oxygen analog and Dimethoate was fed by capsule for 14 days to three lactating cows. The oxygen analog of Dimethoate was fed in the ratio and rates of 0.05:0.50 mg./kg. followed by a second trial using 0.10:1.00 mg./kg. of body weight. At the lower level of intake, cholinesterase was reduced to 73% of normal by the 14th day but none of the oxygen analog

or Dimethoate was detected in the milk. During the second trial cholinesterase activity steadily declined to 53% of normal ten days after feeding had been discontinued. Although no Dimethoate appeared in the milk, 0.01 ppm. of oxygen analog was detected at the upper level of intake. It is concluded that at relatively high levels of intake some of the oxygen analog is excreted in the milk. Further studies are being conducted to determine the amount of oxygen analog remaining in silage after corn forage has been sprayed with as much as 2.0 pounds of Dimethoate per acre. (AH h2-14)

4. Interrelationships between absorption, retention and excretion of DDT and DDE. Some information in the literature indicates that closely related insecticides may affect the absorption, retention and excretion of each other. DDT and DDE were fed singly and in combination to young dairy males. Four and ten weeks after the feeding started total collection balance trials were conducted. DDE did not affect the apparent absorption or retention of DDT. Similarly DDT did not affect DDE absorption or retention beyond the extent to which conversion of DDT to DDE contributed to the DDE pool. From 30% in the first to 50% of the DDT in the second balance trial was metabolized to DDE. This suggests that the mechanism of conversion of DDT to DDE may adapt to the presence of DDT in the ration. After correction for conversion of DDT to DDE, the apparent retention of DDT was 38% during the first balance trial but with no apparent retention in the second at 10 weeks after feeding started. This suggests that the equilibrium of DDT was reached within 10 weeks, at the level of feeding used in the trial. These results suggest that DDT or DDE have no direct effect on the other in terms of retention, absorption or excretion. Thus the feeding of the less toxic DDE would have no effect on the absorption, retention or excretion of DDT. (AH h2-14)

#### PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

##### Digestion and Metabolism

- Flatt, W. P. 1966. Symposium: Re-evaluation of nutrient allowances for high-producing cows. Energy metabolism results with lactating dairy cows. J. Dairy Sci. 49:230-237. (AH h2-8)
- Flatt, W. P. 1965. Energy values of feeds -- How should they be expressed? Proc. 18th Washington Animal Nutrition Conference, Bellevue, Washington, November 9. pp. 13-29. (AH h2-8)
- Flatt, W. P. 1965. Energy requirements of dairy cattle. Proc. 18th Washington Animal Nutrition Conference, Bellevue, Washington, November 9. pp. 56-68. (AH h2-8)
- Flatt, W. P. 1966. As population grows need for efficient feeding becomes critical. 1966 Feed Bag Red Book. Editorial Service Co., Inc. Milwaukee, Wisconsin. March. pp. 9-13. (AH h2-8)



- Flatt, W. P. 1966. Energy values of feeds and energy requirements of dairy cattle. Proc. 21st Kansas Formula Feed Conference. Kansas State Univ., Manhattan, Kansas. January 10-11. pp. 30-42. (AH h2-8)
- Flatt, W. P. 1966. Speaking of nutrition - Calorimetry (No. 1). Feed Age. 16:31-32. Feb. (AH h2-8)
- Flatt, W. P. 1966. Speaking of nutrition - Automation (No. 2). Feed Age. 16:47-48. May. (AH h2-8)
- Flatt, W. P. and Moe, P. W. 1966. Energy use in cattle. Proc. 1966 Virginia Feed Convention and Nutrition Conference. Roanoke, Virginia. Feb. 22-23, 1966. pp. 3-6. (AH h2-8)
- Flatt, W. P., Moe, P. W., Moore, L. A., Hooven, N. W., Lehmann, R. P. and Hemken, R. W. 1966. Energy requirements for milk production. Proc. 21st Distillers Feed Conference. Cincinnati, Ohio. March 9. Vol. 21: 36-46. (AH h2-8)
- Flatt, W. P., Moe, P. W., Moore, L. A., Hooven, N. W., Lehmann, R. P., Ørskov, E. R., and Hemken, R. W. 1966. Energy utilization by high producing dairy cows. J. Dairy Sci. 49:714. (Abs.) (AH h2-8)
- Moe, P. W., Flatt, W. P., and Moore, L. A. 1966. Effect of level of intake on energy losses by dairy cows. J. Dairy Sci. 49:714. (Abs.) (AH h2-8)
- Moe, P. W., Flatt, W. P., and Tabler, K. A. 1966. The role of automation in energy metabolism research with large animals. Proceedings of a symposium sponsored by GSA and OASD on Source Data Automation. Washington, D. C. May 9-11. (AH h2-8)
- Patterson, John L., Jr., Goetz, R. H., Doyle, J. T., Warren, J. V., Gauer, O. H., Detweiler, D. K., Said, S. I., Hoernicke, H., McGregor, M., Keen, E. N., Smith, M.H., Jr., Hardie, E. L., Reynolds, M., Flatt, W. P., and Waldo, D. R. 1965. Cardiorespiratory dynamics in the ox and giraffe, with comparative observations on man and other mammals. Annals New York Academy of Sciences. Vol. 127:393-413. (AH h2-8)
- Smith, L. W., Flatt, W. P., Barnes, K. A., and Van Soest, P. J. 1965. A rapid method of carbon analysis for biological materials. Assoc. Official Agri. Chemists. 48:1261-1265. Dec. (AH h2-8)
- Van Soest, P. J. 1965. Voluntary intake in relation to chemical composition and digestibility. J. Animal Sci. 24:834-843. (AH h2-6)
- Van Soest, P. J. 1965. Use of detergents in analysis of fibrous feeds. III. Study of effects of heating and drying on yield of fiber and lignin in forages. J. Assoc. Off. Agr. Chem. 48: 785-790. (AH h2-6)

Van Soest, P. J. 1966. Nonnutritive residues: A system of analysis for the replacement of crude fiber. J. Assoc. Off. Anal. Chem. 49: 546-551. (AH h2-6)

Van Soest, P. J. 1966. Forage intake in relation to chemical composition and digestibility: Some new concepts. Proc. Southern Pasture Forage Crop Improvement Conference, Blacksburg, Virginia, June. (AH h2-6)

#### Forage Evaluation and Utilization

Baxter, H. D., Owen, J. R., and Montgomery, M. J. 1966. Pearlmillet vs. grain sorghum as silage for dairy cattle. J. Dairy Sci. 49:448. (Abs.) (AH h3-3)

Derbyshire, J. C., Gordon, C. H., and Humphrey, J. L. 1966. The effect of ensiling treatment and stage of maturity on oat silages. J. Dairy Sci. 49:716. (Abs.) (AH h3-3)

Gordon, C. H. 1966. Low-moisture silage preserves more TDN. Hoard's Dairyman. 111:753. June. (AH h3-3)

Gordon, C. H., Derbyshire, J. C., and Humphrey, J. L. 1966. The value of mature corn for silage. ARS 44-176. (AH h3-3)

Gordon, C. H., Derbyshire, J. C., Jacobson, W. C., and Humphrey, J. L. 1965. Effects of dry matter in low-moisture silage on preservation, acceptability and feeding value for dairy cows. J. Dairy Sci. 48:1062-1068. (AH h3-3)

#### Feeding Heifers

Miller, R. W., Hemkin, R. W., Waldo, D. R., Okamoto, M., and Moore, L. A. 1965. Effect of feeding buffers to dairy cows fed a high-concentrate, low roughage ration. J. Dairy Sci. 48:1455-1458. (AH h1-1)

Miller, R. W., Hemken, R. W., Vandersall, J. H., Waldo, D. R., Okamoto, M., and Moore, L. A. 1965. Effects of feeding buffers to dairy cows grazing pearlmillet or sudan grass. J. Dairy Sci. 48:1319-1323. (AH h1-1)

Miller, R. W., Moore, L. A., Waldo, D. R., and Wrenn, T. R. 1965. Effect of nitrate on utilization of corn silage carotene. J. Animal Sci. 24:898. (Abs.) (AH h1-1)

Waldo, D. R., Miller, R. W., Okamoto, M., and Moore, L. A. 1965. Ruminant utilization of silage in relation to hay, pellets and hay plus grain. I. Composition, digestion, nitrogen balance, intake and growth. J. Dairy Sci. 48:910-916. (AH h1-1)



Waldo, D. R., Miller, R. W., Okamoto, M., and Moore, L. A. 1965. Ruminant utilization of silage in relation to hay, pellets, and hay plus grain. II. Rumen content, dry matter passage and water intake. J. Dairy Sci. 48:1473-1480. (AH hl-1)

Waldo, D. R., Smith, L. W., Miller, R. W. and Moore, L. A. 1966. Formic acid silage versus hay for growth. J. Animal Sci. 25:916. (Abs.) (AH hl-1)

## AREA NO. 8: DAIRY CATTLE - MANAGEMENT

Problem: Information on husbandry and farm management practices is needed to enable dairy farmers to lower cost and increase efficiency of herd production. Labor is a major problem and cost item. Good husbandry practices are important and economically important to the efficient production of quality products. Mastitis is the most costly disease in dairy cattle. Dairy farm wastes contribute to environmental contamination. Dairy men need answers to these problems in order to minimize production costs through optimum use of labor, husbandry practices, and farm resources.

### USDA AND COOPERATIVE PROGRAM

This is a continuing program conducted by dairy husbandmen and is aimed at increasing basic and applied knowledge in the management of dairy cattle and herds. Major emphasis is placed on applied research. Specific emphasis is directed toward research on sanitation and quality of products, management control of mastitis, environmental influences on performance, and fly control. Cooperative work is under way at Louisiana, Minnesota, and Wisconsin.

A PL 480 project at Rehovot, Israel, for \$22,081 equivalent annually on reproductive management and liberal feeding of concentrates as a means of higher production was initiated in 1965.

The Federal scientific effort devoted to this area totals 3.2 with 2.5 in quality products and sanitation and 0.7 in environmental influences.

### PROGRESS -- USDA AND COOPERATIVE PROGRAMS

#### A. Quality Products and Sanitation

##### 1. Bovine mastitis.

(a) Diurnal variation in cell content of milk. Daily samplings indicate that cell counts in foremilk samples are lowest just prior to milking, rise sharply during the next 4 hours, drop slightly by 8 hours post-milking, and return to a minimum toward the end of the inter-milking period. The cell count level and magnitude of change varied widely between groups, cows within groups, and between quarters of a cow. In general, the infected quarters followed the same pattern with a higher mean cell count. There was a wide overlap between the counts from the infected and non-infected quarters. These results emphasize the necessity of careful study in selecting an appropriate sample of milk for research on routine health surveys. These data also indicate that there is no definite cell count level that will effectively separate the infected from the non-infected quarters.

(AH g3-10)



(b) Variation in cell content of sequential samples collected at milking time. Cell counts, from quarter foremilk samples obtained before a cow had been stimulated to let her milk down, were materially higher than counts from samples taken after milk let down or from samples of the mixed milk drawn from the quarter at milking time. Cell counts were the highest in stripping samples collected after the removal of the machine. A detailed study of 11 "normal" quarters indicated that cell content decreased from the foremilk until about 1/3 of the milk was removed and increased through the later portion of the milking. Cell counts were very high in the machine strippings, but increased further in two consecutive hand stripped samples. The individual counts were extremely variable and suggest that small partial sampling does not give a reliable indication of the concentration of cells in the mixed quarter milk. (AH g3-8)

(c) Influences of environmental sanitation. A study is in progress designed to determine the effectiveness of strict sanitation in reducing the incidence of mastitis. Initially an attempt is being made to define conditions under which a high rate of natural infection can be induced in a small number of rigorously controlled cows by introducing a pathogen into their environment.

Six cows have completed their first lactation in each of two controlled environment chambers. In one chamber controlled overmilking and generally poor sanitation have been superimposed on exposure to two udder pathogens. The other chamber has served as a highly sanitary control. Despite the demonstrated susceptibility of many of the glands to infection by Streptococcus agalactiae when introduced into the gland, no infections resulted from environmental exposure alone. In a shorter period Staphylococcus aureus showed signs of greater invasiveness. The distribution of infections by miscellaneous microbes indicates that sanitary practices have real importance in control of udder disease. These results reinforce the view that first-lactation cattle are particularly resistant to mastitis, and suggest that the teat sphincter and canal play a major role in this resistance. Continuing studies with older animals will expand these findings. (AH g3-8)

2. Cooling rate effects on milk quality. Investigations at Beltsville were continued to study the effect on raw milk quality of differing rates of cooling in mechanically refrigerated farm bulk tanks. A system was devised wherein milk of differing levels of microbial contamination can be studied under exactly comparable tank cooling conditions. Studies have been initiated to evaluate the effects of varying cooling rates on the normal raw milk supply from the farm, both alone and with the addition of microbial contaminants having specific relation to food deterioration or public health. Preliminary results indicate that, whereas considerable relaxation of current cooling requirements might be adequate for maintenance of quality in the average grade A raw milk supply, it would not prevent an undesirable population increase resulting from the outgrowth of a massive psychrophilic contamination. The multiplication of

Staphylococcus aureus, however, is adequately inhibited at a cooling rate as slow as that which required three hours to cool the first milking in the tank to 50° F. (AH g3-10)

3. Physical methods of fly control. Investigations of physical methods for controlling flies in dairy operations were continued at Beltsville as a cooperative effort among Entomology, Animal Husbandry, and Agricultural Engineering Research Divisions, ARS. A study was initiated to evaluate the effectiveness of farmstead sanitation practices in reducing fly populations and to determine whether efforts by individual farmers are beneficial, or whether concerted community action is essential. Monitoring surveys were made of native fly populations on neighboring farmstead areas and of the dispersal of marked flies released at various points within the area. Removal of fly-attractive materials from a dairy complex appeared to reduce the house fly population by about 1/3. Stable flies were not much affected by barn and corral cleanup. House flies dispersed more rapidly from areas with few breeding sites than from areas with many breeding sites. Houseflies were more attracted to farms with uncleaned corrals and barns than to farms having daily manure cleanup. Most house fly dispersal occurred within 4 days after adult emergence and was quite rapid to farms within a 1-mile radius of the emergence site.

A companion study was initiated through contract with Louisiana State University to evaluate effects of sanitation under the favorable conditions for flies prevailing in the South and to compare the benefits derived from different levels of effort to maintain sanitation on typical farmsteads. Cooperators have been selected and detailed observations will be made during the 1966 and 1967 seasons.

Near the end of the fly season, the effectiveness of filtered 3650 Å ultraviolet as an outdoor attractant for flies was tested with two devices. One, employing a "sticky-board" surface behind a BLB fluorescent lamp, was used in a pasture. The other, in which the lamp was surrounded by gauze impregnated with insecticide, was used in an open loafing shed. The pasture survey showed that more house flies were attracted to the lamps than the other more positively phototropic flies. Similar results were obtained by the survey conducted in the loafing shed. Several face flies were attracted to the lamps in the loafing shed, contrary to the common belief that such flies usually are not found inside barns unless seeking over-wintering sites. (AH g3-12, AH g3-13 (c))

## B. Environmental Influences

1. Environmental influences on production. In cooperation with the University of Wisconsin, studies have been in progress to determine the important environmental variations contributing to changes in milk production. Past results led to the development of an environmental index which accounted for a large amount of the variation among herds. The current research was conducted to determine if the index could minimize



environmental effects on production among herds; thereby making genetic appraisals more accurate. Single visits were made to 100 Holstein herds on standard DHIA. Ten variables were measured during the evening milking. Objective measures were made of vacuum level, pulsation rate, number of machines operated per man, % days in milk, herd size, and kgs. of TDN fed per 455 kgs. of body weight. Subjective scores were given to cow cleanliness, calf feeding, herdsmanship, and hay score. The variables with statistically significant standard partial regression coefficients were % days in milk, hay score, herdsmanship, and calf feeding (.33, .26, .18, and .18%, respectively). The index accounted for 44% of the variation in production among herds. Results from this and the previous work can be used to aid the dairyman in placing proper emphasis on management practices.

Another phase of the study was to determine the usefulness of one day's production and the environmental index for purposes of sire evaluation. Milk production and milk fat test per cow on the day of the visit, as well as measures of the 7 components of the environmental index, were recorded. Proofs for 84 sires with 5 or more daughters in the 100 herds were calculated, using the estimated lactations. The proofs were expressed as deviations from herdmates (1) and deviations from environmental index (2). The criterion for evaluating (1) and (2) was the bull's USDA herdmate comparison (3). Correlations of (3) with (1) and (2) were .11 and .08, respectively, for milk production. Corresponding correlations for milk fat production were .18 and .16. Proofs, using production information from one day, were approximately 20% and 35% as accurate as those expected from complete lactations for milk and milk fat production, respectively. It was concluded that (a) herdmate comparisons are effective in reducing environmental correlations among projected lactations, (b) herdmate comparisons are more accurate than herd index comparisons using projected lactations, (c) three to five times as many projected lactations should predict sire proofs as accurately as complete lactations, and (d) because of simplicity of computation, herd index comparisons may be useful in preliminary evaluation of sires using projected lactations.

At Minnesota a separate study was made to evaluate genetic and environmental sources of variation in the population. The population consisted of 618,923 progeny records of 432 Holstein-Friesian sires having a minimum of 200 production tested daughters. These records were provided from the Dairy Branch sire summary files. Intra-sire regression of progeny records on herdmate averages for milk and fat were .88 and .89. Heritability of herd differences for milk and fat was .23 and .22. Genetic standard deviations for milk and fat yield estimated from sire components were 491.16 and 17.66 kg., respectively.

The percent of the environmental variation accounted for by expressing lactation records as deviation from herdmates was regions, 76.64; years, 98.86; seasons, 85.31; region x year x season, 17.03; and month, 77.65. It is concluded that present procedures of sire evaluation in use by the USDA are doing an effective job in minimizing nongenetic sources of variation among sires used in multiple herds. (AH g5-1)

2. Measuring learning ability in dairy cows. At Wisconsin, learning ability was studied in 2 groups of 10 dairy calves 3 to 6 months of age. Visual association with feed as a positive reinforcement was used. Each animal was subjected to 2 indoctrination sessions, 10 alternation sessions, and 5 random sessions. Each session consisted of 10 trials. The testing device was a 4 x 10-ft. enclosed alley, divided at one end. The visual stimuli were two pails, one black and one white, on either side of the division. Items recorded were session number, trial number, time for a response, and time for a correct response. Percent correct responses, mean time for a response, and mean time for a correct response for all calves were 88.2%, 6.54 seconds, and 7.78 seconds, respectively. A logarithmic curve fitted to session means and a cyclic curve fitted to trial means accounted for 98% and 76%, respectively, of the variation in percent correct responses. An exponential curve fitted to the mean time per session across trials accounted for 89% of the variation in percent correct responses. The learning curves indicated that a minimum of five sessions with five trials per session should accurately estimate genetic parameters for this characteristic. (AH g5-1)

3. Influence of management practices and environmental factors on adaptability. At the National Dairy Research Institute, Karnal, India, studies of the utilization of nutrients for milk production of Red Sindhi, Sahiwal, and Tharparkar cows revealed that milk production up to 10 kg. per day could be achieved by feeding berseem alone. Concentrate supplementation was required at higher levels of production. Berseem feeding alone resulted in deficiencies of phosphorous and magnesium. During the summer months when the majority of feed was non-leguminous, only maintenance requirements could be met from roughages alone. Cost accounting records showed the overall cost of feeding per unit of milk produced was much less in winter due to the high cost of concentrates. Efficiency of feed utilization for milk production was highest in the Tharparkar breed. It was concluded that maintenance and production requirements can be adequately provided from good roughage with mineral supplement, and at a lower cost than with the use of concentrates. (A7-AH-6)

#### PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

##### Quality Products and Sanitation

Schultze, W. D. and Smith, J. W. 1966. The cellular content of cows milk. II. Comparison of the California mastitis test and microscopic count for estimating cell concentration in quarter samples. J. Milk and Food Tech. 29:126-128. (AH g3-8)

Smith, J. W. and Schultze, W. D. 1966. The cellular content of cows milk. I. An evaluation of the California mastitis test as a method of estimating the number of cells in milk. J. Milk and Food Tech. 29:84-87. (AH g3-8)



Smith, J. W. and Schultze, W. D. 1966. Variation in cell content of milk associated with time of sample collection. J. Dairy Sci. 49:738 (Abs.) (AH g3-8)

#### Environmental Influences

Barr, G. R., Wieckert, D. A., and Hansen, L. R. 1966. Environmental adjustments for sire proofs. J. Dairy Sci. 49:736 (Abs.) (AH g5-1)

Conlin, B. J. and Cole, C. L. 1966. Estimates of parameters from a nation wide artificial insemination population. J. Dairy Sci. 49:748 (Abs.) (AH g5-1)

Hansen, L. R., Barr, G. R., and Wieckert, D. A. 1966. Environmental influences on production in 100 dairy herds. J. Dairy Sci. 49:729 (Abs.) (AH g5-1)

Wieckert, D. A., Johnson, L. P., Offord, K. P., and Barr, G. R. 1966. Measuring learning ability in dairy cows. J. Dairy Sci. 49:729 (Abs.) (AH g5-1)

Related Publications of State Experiment Stations

- Albright, J. L., Young, J. O., Moeller, N. J. and Cavanaugh, V. 1965.  
A Survey of Dairy Cattle Housing in Indiana.  
J. Milk and Food Tech. 28(2):45-47. Indiana
- Alexander, C. L., Bartley, E. E., Morrill, J. L. and Meyer, R. E. 1965  
Techniques to Determine Rate of Metabolism of C<sup>14</sup> Labeled Alfalfa in  
the Bovine Rumen.  
J. Dairy Sci. 48(7):924-929. Kansas
- Arroyo-Aguilu, J. A., and Rivera-Brenes, L. 1965.  
Relationship Between the Percentages of Crude Protein and Apparently  
Digestible Protein in Some Forages of Puerto Rico.  
J. Agri. Univ. P. R. 49(1):145-148. Puerto Rico
- Arroyo-Aguilu, J. A. and Rivera-Anaya, J. D. 1965.  
Plastic Cannula for Rumen Fistula.  
J. Agri. Univ. P. R. 49(2):269-270. Puerto Rico
- Atai, S. R. and Harshbarger, K. E. 1965.  
Effect of Substituting Dry Sugars for Molasses in Calf Starters on Feed  
Intake and Growth Response.  
J. Dairy Sci. 48(3):391-394. Illinois
- Baldwin, R. L., Wood, W. A. and Emery, R. S. 1965.  
Lactate Metabolism by Peptostreptococcus elsdenii: Evidence for Lactyl  
Coenzyme A Dehydrase.  
Biochim. Biophys. Acta. 97:202-213. California
- Bartley, E. E., Lippke, H., Pfost, H. B., Nijweide, R. J., Jacobson, N. L.  
and Meyer, R. M. 1965.  
Bloat in Cattle. X. Efficacy of Poloxalene in Controlling Alfalfa Bloat  
in Dairy Steers and in Lactating Cows in Commercial Dairy Herds.  
J. Dairy Sci. 48(12):1657-1662. Kansas
- Bauman, J. R. and Turner, C. W. 1965.  
Oral Effectiveness of L-Thyroxine, L-Triiodothyronine, and Thyroprotein  
as Compared to Injections of L-Thyroxine and Thyroprotein.  
J. Dairy Sci. 48(10):1353-1356. Missouri
- Byers, J. H. 1965.  
Comparison of Feeding Value of Alfalfa Hay, Silage, and Low Moisture  
Silage.  
J. Dairy Sci. 48(2):206-208. Illinois
- Byers, J. H., Kendall, K. A. and Ormiston, E. E. 1965.  
Feeding Value of Dwarf Corn Silage Compared with Corn and Hybrid Sorghum  
Silages.  
J. Dairy Sci. 48(2):203-205. Illinois



Calhoun, M. C., Rousseau, J. E. Jr., Hall, R. C., Jr., Eaton, H. D.,  
Nielsen, S. W. and Lucas, J. J. 1965.

Cisternal Cerebrospinal Fluid Pressure During Development of Chronic  
Bovine Hypervitaminosis A.

J. Dairy Sci. 48(6):729-732.

Connecticut

Colovos, N. F., Peterson, N. K., Blood, P. T. and Davis, H. A. 1965.  
The Effect of Rate of Nitrogen Fertilization, Geographic Location and  
Date of Harvest on Yield, Acceptability, and Nutritive Value of  
Timothy Hay.

N. H. Agr. Expt. Sta. Bul. 486.

New Hampshire

Colvin, H. W. Jr. and Daniels, L. B. 1965.

Rumen Motility as Influenced by Physical Form of Oat Hay.

J. Dairy Sci. 48(7):935-941.

Arkansas

Cook, R. M., Brown, R. E., and Davis, C. L. 1965.

Protein Metabolism in the Rumen. I. Absorption of Glycine and Other  
Amino Acids.

J. Dairy Sci. 48(4):475-483.

Illinois

Cook, R. M. and Miller, L. D. 1965

Utilization of Volatile Fatty Acids in Ruminants. I. Removal of Them  
From Portal Blood by the Liver.

J. Dairy Sci. 48(10):1339-1345.

Idaho

Elliot, J. M., Hogue, D. E., and Tyrrell, H. F. 1965.

Blood Vitamin B<sub>12</sub> Status of the Dairy Cow in Late Pregnancy and Early  
Lactation.

J. Dairy Sci. 48(10):1335-1338.

New York

Emery, R. S., Brown, L. D. and Bell, J. W. 1965.

Correlation of Milk Fat With Dietary and Metabolic Factors in Cows Fed  
Restricted Roughage Rations Supplemented With Magnesium Oxide or Sodium  
Bicarbonate.

J. Dairy Sci. 48(12):1647-1651.

Michigan

Engel, R. W., Young, R. W., Samuels, B. L. and Midyette, J. W. Jr. 1965.  
Heptachlor Persistence in the Alfalfa-Production Environment.

J. Dairy Sci. 48(8):1101-1105.

Virginia

Fenner, H. and Barnes, H. D. 1965.

Improved Method for Determining Dry Matter in Silage.

J. Dairy Sci. 48(10):1324-1328.

Massachusetts

Haenlien, G. F. W., and Richards, C. R. 1965.

The Nutritive Value of Silage Made From Vines of Lima Beans (Phaseolus  
lunatus L.

Del. Agr. Exp. Sta. Bul. 358.

Delaware

Harshbarger, K. E., Ormiston, E. E., Staubus, J. R. and Johnson, R. V.  
Apr. 1965.

A Nutritional Assessment of Methods of Harvesting Summer Forage for  
Dairy Cows.

Ill. Agr. Exp. Sta. Bul. 709.

Illinois

Helmer, L. G., Bartley, E. E. and Meyer, R. M. 1965.

Bloat in Cattle. IX. Effect of Poloxalene, Used to Prevent Legume Bloat  
on Milk Production, Feed Intake, Health Reproduction and Rumen  
Fermentation.

J. Dairy Sci. 48(5):575-579.

Kansas

Hinders, R. G., and Owen, F. G. 1965.

Relation of Ruminant Parakeratosis Development to Volatile Fatty Acid  
Absorption.

J. Dairy Sci. 48(8):1069-1073.

Nebraska

Hodson, H. H., McGilliard, A. D., Jacobson, N. L. and Allen, R. S. 1965.  
Metabolic Role of Rumen Mucosa in Absorption of Butyrate.

J. Dairy Sci. 48(12):1652-1656.

Iowa

Jainudeen, M. R., Hansel, W. and Davison, K. L. 1965.

Nitrate Toxicity in Dairy Heifers. 3. Endocrine Responses to Nitrate  
Ingestion During Pregnancy.

J. Dairy Sci. 48(2):217-221.

New York

Jorgensen, N. A., Schultz, L. H. and Barr, G. R. 1965.

Factors Influencing Milk Fat Depression on Rations High in Concentrates.  
J. Dairy Sci. 48(8):1031-1039.

Wisconsin

Jorgensen, N. A. and Schultz, L. H. 1965.

Ration Effects on Rumen Acids, Ketogenesis, and Milk Composition.  
II. Restricted Roughage Feeding.

J. Dairy Sci. 48(8):1040-1045.

Wisconsin

Jumah, H. F., Poulton, B. R., and Apgar, W. P. 1965.

Energy and Protein Utilization During Lactation.

J. Dairy Sci. 48(9):1210-1214.

Maine

Komkris, T., Stanley, R. W. and Morita, K. 1965.

Effect of Feed Containing Molasses Fed Separately and Together with  
Roughage on Digestibility of Rations, Volatile Fatty Acids Produced  
in the Rumen, Milk Production and Milk Constituents.

J. Dairy Sci. 48:714-719.

Hawaii

Laben, R. C., Archer, T. E. Crosby, D. G. and Peoples, S. A. 1965.

Lactational Output of DDT Fed Prepartum to Dairy Cows.

J. Dairy Sci. 48(6):701-708.

California



Mayton, E. L., Hawkins, G. E., Blackstone, J. H. and Little, J. A. 1965.  
Forage Systems Compared for High Producing Cows.  
Ala. Agr. Exp. Sta. Bul. 363. Alabama

McCullough, M. E., Sisk, L. R. and Sell, O. E. 1965.  
Silage Characteristics for Optimum Production in Dairy Animals.  
Tech. Bull. N. S. 43. Ga. Exp. Stations. May. Georgia

McKinney, W. H., Welch, H. K., and Fosgate, O. T. 1965.  
Estimations of Certain Environmental Influences on Milk Production Based  
Upon Dairy Herd Improvement Association Data.  
J. Dairy Sci. 48(3):361-364. Georgia

Meyer, R. M., Bartley, E. E. and Deyoe, C. W. 1965.  
Bloat in Cattle. VII. Relation to Amino Acid Composition of Alfalfa as  
Affected by Maturity.  
J. Dairy Sci. 48(2):213-216. Kansas

Miller, J. K. and Cragle, R. G. 1965.  
Gastrointestinal Sites of Absorption and Endogenous Secretion of Zinc in  
Dairy Cattle.  
J. Dairy Sci. 48(3):370-373. Tennessee

Miller, J. K., Swanson, E. W. and Hansen, S. M. 1965.  
Effects of Feeding Potassium Iodide, 3,5-Diiodosalicylic Acid or  
L-Thyroxine on Iodine Metabolism of Lactating Dairy Cows.  
J. Dairy Sci. 48(7):888-894. Tennessee

Miller, R. W., Hemken, R. W. Vandersall, J. H., Waldo, D. R., Okamoto, M.  
and Moore, L. A. 1965.  
Effect of Feeding Buffers to Dairy Cows Grazing Pearl Millet or Sudan  
Grass.  
J. Dairy Sci. 48(10):1319-1323. Maryland

Miller, R. W. Hemken, R. W., Waldo, D. R., Okamoto, M. and Moore, L. A.  
1965.  
Effect of Feeding Buffers to Dairy Cows Fed a High-Concentrate, Low-  
Roughage Ration.  
J. Dairy Sci. 48(11):1455-1458. Maryland

Miller, W. J. and Clifton, C. M. 1965.  
Relation of Dry Matter Content of Ensiled Material and Other Factors to  
Nutrient Losses by Seepage.  
J. Dairy Sci. 48(7):917-923. Georgia

Miller, W. J., Clifton, C. M., Brook, O. L. and Beaty, E. R. 1965.  
Influence of Harvesting Age and Season on Digestibility and Chemical  
Composition of Pelleted Coastal Bermudagrass.  
J. Dairy Sci. 48(2):209-212. Georgia

- Miller, W. J., Clifton, C. M., Fowler, P. R. and Perkins, H. F. 1965.  
Influence of High Levels of Dietary Zinc on Zinc in Milk. Performance  
and Biochemistry of Lactating Cows.  
J. Dairy Sci. 48(4):450-453. Georgia
- Miller, W. J., Clifton, C. M., Miller, J. K. and Fowler, P. R. 1965.  
Effects of Feeding Unlike Forages, Singly and in Combination on Voluntary  
Dry Matter Consumption and Performance of Lactating Cows.  
J. Dairy Sci. 48(8):1046-1052. Georgia
- Miller, W. J., Pitts, W. J., Clifton, C. M. and Morton, J. D. 1965.  
Effects of Zinc Deficiency per se on Feed Efficiency, Serum Alkaline  
Phosphatase, Zinc in Skin, Behavior, Greying, and Other Measurements  
in the Holstein Calf.  
J. Dairy Sci. 48(10):1329-1334. Georgia
- Moe, P. W., Reid, J. T. and Tyrrell, H. F. 1965.  
Effect of Level of Intake on Digestibility of Dietary Energy by High-  
Producing Cows.  
J. Dairy Sci. 48(8):1053-1061. New York
- Montgomery, M. J. and Baumgardt, B. R. 1965.  
Regulation of Food Intake in Ruminants. 1. Pelleted Rations Varying in  
Energy Concentration.  
J. Dairy Sci. 48(5):569-574. Wisconsin
- Montgomery, M. J. and Baumgardt, B. R. 1965.  
Regulation of Food Intake in Ruminants. 2. Rations Varying in Energy  
Concentrations and Physical Form.  
J. Dairy Sci. 48(12):1623-1628. Wisconsin
- Nicolai, J. H. and Stewart, W. E. 1965.  
Relationship Between Forestomach and Glycemia in Ruminants.  
J. Dairy Sci. 48(1):56-60. Maryland
- Ott, E. A., Smith, W. H., Stob, M., Parker, H. E. and Beeson, W. M. 1965.  
Zinc Deficiency Syndrome in the Young Calf.  
J. Animal Sci. 24(3):735-741. Indiana
- Owen, F. G. and Howard, W. T. 1965.  
Effect of Ration Moisture Level on Value of Alfalfa Plus Cracked Corn as  
a Complete Feed Silage for Lactating Cows.  
J. Dairy Sci. 48(10):1310-1314. Nebraska
- Pratt, A. D. and Conrad, H. R. 1965.  
The Need for Unfermented Grain or Forage with High-Moisture Grass-Legume  
Silage for Dairy Animals.  
Ohio Agr. Res. & Development Center Res. Bul. 979. Ohio



- Randel, Paul F. 1965.  
Comparison of Simple vs. Complex Concentrate Mixtures for Dairy Cattle in  
Puerto Rico: Feeding Lactating Cows Receiving Fair-Quality Forage.  
J. Agr. Univ. P. R. 49(3):331-341. Puerto Rico
- Randel, Paul F. 1965.  
Comparison of Simple vs. Complex Concentrate Mixtures for Dairy Cattle in  
Puerto Rico: Feeding Heifers in Dry Lot.  
J. Agr. Univ. P. R. 49(3):342-349. Puerto Rico
- Rathore, A. K. 1965.  
Diurnal and Nocturnal Variations in the Ruminal Contractions, Respiration  
Rate, Pulse Rate and Temperature and Their Interrelationship in Lactating  
Holstein Cows.  
Brit. Vet. J. 121:483-487. New Jersey
- Reid, R. L. and Jung, G. A. 1965.  
Influence of Fertilizer Treatment on the Intake, Digestibility and  
Palatability of Tall Fescue Hay.  
J. Animal Sci. 24(3):615-625. West Virginia
- Rust, J. W., Jacobson, N. L., McGilliard, A. D. and Hotchkiss, D. K. 1965.  
Supplementation of Dairy Calf Diets with Enzymes. II. Effect on Nutrient  
Utilization and on Composition of Rumen Fluid.  
J. Animal Sci. 24:156-160. Iowa
- Simkins, K. L. Jr., Baumgardt, B. R. and Niedermeier, R. P. 1965.  
Feeding Value of Calcium Carbonate Treated Silage for Dairy Cows.  
J. Dairy Sci. 48(10):1315-1318. Wisconsin
- Simmons, K. R., Dracy, A. E. and Essler, W. O. 1965.  
Diurnal Temperature Patterns in Unrestrained Cows.  
J. Dairy Sci. 48(11):1490-1493. Vermont
- Simkins, K. L. Jr., Suttie, J. W. and Baumgardt, B. R. 1965.  
Regulation of Food Intake in Ruminants. 3. Variation in Blood and Rumen  
Metabolites in Relation to Food Intake.  
J. Dairy Sci. 48(12):1629-1634. Wisconsin
- Simkins, K. L. Jr., Suttie, J. W. and Baumgardt, B. R. 1965.  
Regulation of Food Intake in Ruminants. 4. Effect of Acetate, Propionate,  
Butyrate, and Glucose on Voluntary Food Intake in Dairy Cattle.  
J. Dairy Sci. 48(12):1635-1642. Wisconsin
- Speicher, J. A. and Lassiter, C. A. 1965.  
Influence of Specified Farm Management Factors on Dairy Farm Net Income.  
J. Dairy Sci. 48(12):1698-1703. Michigan

- Stott, G. H. 1965.  
Parturient Paresis Related to Dietary Phosphorus.  
J. Dairy Sci. 48(11):1485-1489. Arizona
- Swanson, E. W., Miller, J. K. and Cragle, R. G. 1965.  
Metabolism of Different Forms of Iodine in Milk Given to Calves by  
Suckling and Rumen Infusion.  
J. Dairy Sci. 48(7):930-934. Tennessee
- Tyrrell, H. F. and Reid, J. T. 1965.  
Prediction of the Energy Value of Cow's Milk Milk.  
J. Dairy Sci. 48(9):1215-1223. New Jersey
- Ueyama, E., Davis, C. L. and Wolin, M. J. 1965.  
Lack of Influence of Spermine or Diet on Calf Spermine Oxidase Formation.  
J. Dairy Sci. 48(1):73-76. Illinois
- Wagner, D. G., Loosli, J. K., Hintz, H. F. and Warner, R. G. 1965.  
Value of Soybran Flakes for Milk Production.  
J. Dairy Sci. 48(5):553-555. New York
- Woelfel, C. G., Hall, R. C. Jr., Calhoun, M. C., Rosseau, J. E., Jr.,  
Eaton, H. D., Nielsen, S. W., Kersting, E. J. and Lucas, J. J. 1965.  
Volume and Osmolality of Urine of Hypovitaminatic A Holstein Heifers.  
J. Dairy Sci. 48(10):1346-1352. Connecticut
- Yang, M. G. and Thomas, J. W. 1965.  
Absorption and Secretion of Some Organic and Inorganic Constituents and  
the Distribution of These Constituents Throughout the Alimentary Tract  
of Young Calves.  
J. Nutrition 87:444-458. Michigan
- Young, J. W., Tove, S. B. and Ramsey, H. A. 1965.  
Metabolism of Acetate, Propionate, and N-Butyrate in Young Milk-Fed Calves.  
J. Dairy Sci. 48(8):1079-1087. North Carolina
- Zeremski, D., Van Horn, H. H., McGilliard, A. D. and Jacobson, N. L. 1965.  
Effect of the Net Energy Concentration of Total Ration on Milk Production  
and Composition.  
J. Dairy Sci. 48(11):1467-1472. Iowa



## AREA NO. 9: POULTRY - BREEDING

Problem. Considerable progress has been made by both the broiler and egg industries in producing competitively priced and nutritious foods. Due to the lack of new genetic material, improvements from line-crossing have been declining and new methods of attaining progress are needed. The necessary genetic information can be obtained from experimental studies of selection methods and mating systems, from single trait selection studies yielding information on correlated responses, and from experiments on the relative responses of differing genetic material to various environmental conditions. The biochemical basis of gene action in the fowl is largely unknown and is particularly needed in the case of protein synthesis. Cytological information in poultry is limited and considerable emphasis should be given this avenue to improvement. Biochemical and cytological findings may have application in direct identification of genetic differences rather than the somewhat inefficient differentiation based on phenotypic differences.

### USDA AND COOPERATIVE PROGRAM

This is a continuing long-term program of fundamental and applied studies on the genetic improvement of meat and egg production in poultry. Scientists with majors in genetics, cytology or biochemistry and minors in statistics or physiology conduct this research. Much of the research is conducted within the framework of four regional projects. In addition to major contributions to the establishment and maintenance of central facilities, the USDA also provides coordinating personnel at Athens, Georgia; Lafayette, Indiana; and Beltsville, Maryland. The close working relationship between the USDA and State experiment stations in the four regional projects provides for integrated research on a large scale without duplication of effort.

Research at Beltsville, Maryland, involves the following studies: selection for a nutritional deficiency and the effect of such selection on egg production; the biochemical basis for differences in such lines; selection for response in egg production to "18-hour" days in cooperation with AERD; selection for increased body weight under stress conditions with quail; the biochemistry of mutant hemoglobin types in the fowl; and cytological bases for parthenogenesis and inter-species crosses in birds.

The North Central region is concerned with the improvement of egg production through studies of different selection methods and mating systems. The work is conducted at the North Central Regional Poultry Breeding Laboratory, Lafayette, Indiana, and at 8 cooperating State experiment stations. In the Southern region the emphasis is divided between egg and broiler traits and the work, involving genotype x environment interactions,

is conducted at the Southern Regional Poultry Genetics Laboratory, Athens, Georgia, and at 8 cooperating State experiment stations. Cooperative work in the Northeastern region involves the improvement of chickens through genetic and physiological studies and is conducted at 8 cooperating State experiment stations. Cooperative work on reproductive problems of turkeys is carried on with 3 Western State stations.

Public Law 480 research projects are in progress or have been initiated as follows: The Animal and Poultry Breeding Department, Ministry of Agriculture, Dekki Gisa, Egyptian Region, U.A.R., is conducting a study to improve and evaluate the Fayoumi and Dandarawi fowl. A study of the effect of environmental stresses on Tribolium is being conducted in Spain at the Instituto Nacional de Investigaciones Agronomicas, Madrid, Spain. The Hebrew University, Faculty of Agriculture, Rehovot, Israel, is studying bacteriological problems involved in artificial insemination of hens. A study to evaluate native Indian fowl as new sources of germ plasm is being conducted by the Punjab Agricultural University, Ludhiana, India. The University of Udaipur, Udaipur, India, is evaluating the Desi strain as a pure line and in crosses with White Leghorns and Rhode Island Reds.

A total of 7.0 scientific Federal man-years is devoted to this program annually. Of this number 3.7 man-years are devoted to genetics and interrelations of performance traits, and 3.3 to selection and systems of breeding.

#### PROGRAM OF STATE EXPERIMENT STATIONS

The total research effort on poultry breeding by State agricultural experiment stations is 38.5 scientific man-years.

#### PROGRESS -- USDA AND COOPERATIVE PROGRAMS

##### A. Genetics and Interrelations of Performance Traits

1. Biochemical basis for genetic differences in growth rate. Evaluation of individual sire families for differences in utilization of dietary methionine was continued. The growth performance of the progeny of 4 dam families within each of 25 sire families was measured when each dam family was provided daily with an identical quantity of methionine deficient diet. The difference in 3-week weight gains between the best and the poorest sire families was 18 grams (20%). In a previous study, this difference was 21 grams (30%). It was concluded that sire families differ in growth response when fed identical quantities of methionine deficient diet. To test whether this difference in growth response would be reflected as a change in methionine requirement, a series of five diets containing graded levels of methionine was fed to replicate groups of progeny from the 4 best and the 4 poorest sire families as determined in the previous study. Although the progeny from the best sire families outperformed those from the poorest



at every level of methionine supplementation, no differences in methionine requirement were noted. (AH el-52)

2. Selection for egg production under sub-circadian periodicities.

Percent hen-day egg production was 3 percentage points above the randombred control for the F3 generation of White Leghorns maintained under 18-hour "short days." This is somewhat lower than the 5 percentage points difference noted in the previous generation. Egg production of the population maintained under 24-hour days continued to increase to a level of 82.8%, 6.6 percentage points above the control, during the past year. The 18-hour population continued to mature approximately one week later than the 24-hour population. Differences in other economic traits were small. An electronic data recording system has been placed in both houses (18 hour and 24 hour) during the past year. This system is designed to record the time of lay of each egg in an attempt to obtain complete information on the ovulatory sequences of the birds under both environments. This information is punched directly on an 8-channel tape (IBM format) for analysis. (AH el-47)

3. Genetic aspects of selection plateaus in Japanese quail.

In an attempt to investigate a possible method of circumventing apparent selection plateaus for economic traits in the domestic fowl, a study has been initiated utilizing Japanese quail. In order to obtain the maximum number of generations per year, this preliminary work involves selection for 4-week body weight in the quail. The selection response of two lines, one fed a high protein (28%) diet and one a low protein (20% + .1% thiouracil) diet, are being investigated in this study. Progress has been made in both lines through generation 3. In the high protein line, deviation from control has been 3.2, 11.0 and 15.2 grams in generations 1, 2 and 3, respectively. The comparable figures for the low protein line are 3.0, 8.8 and 8.9 grams. Females from the low protein line appear to mature later than those from the high protein line. Fertility levels of the low protein line also appear to be superior to those of the high protein line. Other differences appear to be small.

4. Cytogenetic studies of avian species.

Methods for freeze sectioning egg yolks have been developed. Stains have been tested and appropriate ones selected to differentiate nuclei from egg yolk granules. These techniques will be used in the studies of chromosome duplication associated with parthenogenesis in turkeys, chickens and quail. Several inter-species hybrids have been produced for use in studies of meiosis in such hybrids. (AH el-56)

5. Genotype-environment interactions.

Studies to identify specific genotype-environment interactions in both egg and meat production stocks were conducted as a part of the Southern Regional Poultry Breeding Project. In general, these first studies indicate a small stock x location interaction component when compared to the total phenotypic variation. In some cases this was true even though the interaction was statistically significant. The expression of the interaction term as a percentage of the total

variance appears to be more realistic than expressing it in terms of levels of probability. (AH el-44)

## B. Selection and Systems of Breeding

1. Evaluation of genetic changes produced by various breeding systems. Studies designed to evaluate breeding systems and selection methods were continued at the central facilities of the North Central Regional Poultry Breeding Laboratory and at five cooperating State stations. Three random-bred control populations are maintained and made available to cooperators as foundation stock and controls. Eggs from these control stocks are shipped to many locations throughout the country upon request. Selection at each station is for one trait, hen-day percent egg production to 300 days of age. Other traits are observed but are not the basis for selection. Selection pressure in the project is maintained at approximately 25%.

The Indiana station completed tests of the fourth generation of closed flock, index selection systems, and reciprocal recurrent selection involving the Purdue Pool and Cornell Control populations. Fourth generation tests were also made of crosses of the index selected lines and of index selection within a cross of the Purdue Pool and Cornell Control populations. Index selection in each of the two control populations and the crosses of these two selected lines continued to show some improvement in egg production. Egg size continues to show a decline in these populations. Index selection within the cross of the two control lines and reciprocal recurrent selection show no apparent change in egg production.

The Kansas station project is similar in design and purpose to the Indiana project. The Regional Red Control is used as one of the parent lines rather than the Purdue Pool used by Indiana. Results from the Kansas project indicate that family index selection in the pure lines and their cross has been more effective than reciprocal recurrent selection in increasing egg production. The reciprocal recurrent system, however, does show a positive deviation from control indicating that some progress is being made. A decrease in egg weight is apparent in those populations which are increasing in egg production.

The Missouri station completed the sixth generation of selection on the following systems: Intraflock, in which selection is based on a performance index: crosses of inbred male tester lines with segregating female lines (recurrent selection); and selection within the three Leghorn female lines used in the recurrent selection program. Selection was based on percent hen-day egg production to 34 weeks of age. Randombred controls were obtained from the Regional Laboratory. The three Leghorn female lines and the three male tester lines are designated as La, Lc, Ld and Ll, R3, W4, respectively. The intraflock, crosses and family selection systems were 5, 6 and 8 percentage points, respectively, above the performance of the controls for production to 34 weeks. Within the crosses R3xLc was 10



percentage points above the controls while (L1 x La) and (W4 x Ld) were 3 and 4 percentage points, respectively, above the controls. The average egg weight of the R3 x Lc population was 54 grams (6 grams less than the randombred controls) while the (W4 x Ld) and (L1 x La) populations had average egg weights of 59 and 61 grams, respectively. With the exception of intraflock, all populations showed an egg weight less than the controls, indicating a negative relationship between production and egg weight. All three types (intraflock, crosses and family) showed fewer days to sexual maturity (16, 12 and 7, respectively) than the controls.

At the South Dakota station individual selection for egg production was continued in the White Leghorn population. Also, six "select" sired lines and six "random" sired lines of White Leghorns were continued. Non-inbred lines of Barred Plymouth Rocks and Rhode Island Reds were kept for crossing purposes. The 12-month hen-housed egg production for the control pens averaged 210 eggs. When inbred rather than control sires were used, the average was 214. When inbred line dams were crossed with RIR sires the average was 248, suggesting that crossbreeding appreciably increases the total number of eggs laid. Also, cross-bred production was 10 percentage points higher than the controls. Egg size of crossbreds was about 2 ounces per dozen heavier than for the White Leghorn groups. Sexual maturity in the purebred Leghorns and Rhode Island Reds and crosses of these was relatively late, with a range of 202-208 days.

Forty-two populations were compared under a standard environment at the Regional Laboratory. Except for three populations all were tested with three replicates of 30 birds each. Sixteen traits of economic interest were measured. Selection systems are compared via deviations from appropriate controls. The three control populations are apparently remaining quite stable for the 16 traits measured. Twelve of the 17 selection systems originating from the Cornell Controls ranked above the Cornell Control in percent hen-day production to 500 days of age. Three of these systems were significantly superior to the controls; sire family selection with restricted inbreeding, index selection (individual, sire and dam) and a recurrent selection system. It appears at this time that individual and family selection are superior to reciprocal recurrent or recurrent selection; however, a statistical analysis of several years' data will be necessary before any probabilities can be assigned to such conclusions.

Inbreeding with and without selection was continued at the Wisconsin station. After four generations of full sib matings in the Leghorn populations, the non-selected inbreds were approximately 22 percentage points below the randombred control and non-inbred selected population. The selected inbred populations were approximately 15 percentage points below the control. Other trends noted in the inbreds were increased mortality, delayed sexual maturity and increased floor laying.

As in past years, there appears to be a tendency for increased egg production to be associated with smaller egg size, poorer egg quality, and thinner shelled eggs. (AH el-43)

2. Ranombred control populations. Five ranombred control populations were maintained for use by cooperators as a gene pool and as genetic and environmental controls. Three populations are maintained at Lafayette, Indiana, primarily for egg production research and two at Athens, Georgia, for meat production research. Hatching eggs from these stocks are supplied to cooperating universities, to random sample tests, to universities outside the region, and to commercial poultry breeders. (AH el-43, 44)



PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Genetics and Interrelations of Performance Traits

- Kinney, T. B., Jr. and Shoffner, R. N. 1965. Heritability estimates and genetic correlations among several traits in a meat-type poultry population. Poultry Sci. 44: 1020-1032. (AH el-43)
- Lepore, P. D. 1965. Heritability estimates for hemoglobin and serum protein concentration in growing chickens. Poultry Sci. 44: 1393. (AH el-52)
- Lowe, P. C. and Wilson, S. P. 1965. Interspecies blood injections. Poultry Sci. 44: 1340-1341. (AH el-43)
- Marks, H. L. and Lepore, P. D. 1965. A simple intravaginal technique for the artificial insemination of Japanese quail. Poultry Sci. 44: 1396-1397. (AH el-47)
- Shoffner, R. N. 1965. Current knowledge about the chromosomes in the fowl. World's Poultry Sci. Jour. 21: 157-165. (AH el-43)
- Wearden, S., Tindell, D. and Craig, J. V. 1965. Use of a full diallel cross to estimate general and specific combining ability in chickens. Poultry Sci. 44: 1043-1053. (AH el-43)

Selection and Systems of Breeding

- Morgan, Walter and Carlson, C. W. 1965. Selective efficiency. Poultry Sci. 44: 1401. (AH el-43)
- Nordskog, A. W. 1965. The side effects of selection for single traits. Proc. National Poultry Breeders' Roundtable, pp. 1-17. (AH el-43)
- Saadeh, H. R., Craig, J. V., Smith, L. T. and Wearden, S. 1965. Family index vs. reciprocal recurrent selection compared experimentally. Poultry Sci. 44: 1410-1411. (AH el-43)
- Stephenson, A. B., Kinder, Q. B. and Funk, E. M. 1965. Selection for egg production within crossbred chickens. Poultry Sci. 44: 925-936. (AH el-43)

Related Publications of State Experiment Stations

Genetics and Interrelations of Performance Traits

- Bower, Raymond K., Gyles, N. Roy and Brown, Connell J. 1965. The number of genes controlling the response of chick embryo chorioallantoic membranes to tumor induction by Rous Sarcoma Virus. Genetics 51 (5), pp. 739-746. Arkansas.
- Craig, J. V. and Baruth, R. A. 1965. Inbreeding and social dominance ability in chickens. Animal Behavior 13 (1), pp. 109-113. Kansas.
- Crawford, R. D. and Smyth, J. Robert, Jr. 1965. The influence of comb genotype on mating behavior in the domestic fowl. Poul. Sci. 44 (1), pp. 115-122. Massachusetts.
- Francis, D. W., Roberson, R. H. and Finkner, M. D. 1965. Composition and growth of the heart for three strains of White Leghorns. Growth 29, pp. 193-200. New Mexico.
- Hammond, Mary, Boone, M. A., Barnett, B. D. and Turk, D. E. 1965. Studies of the composition of the deoxyribonucleic acid of the fowl spermatozoon. J. Reprod. Fertil. 9, pp. 347-349. S. Carolina.
- Hawes, Robert O. and Buss, Edward G. 1965. The use of the riboflavinless gene (rd) in determining the cause of clubbed down. Poul. Sci. 44 (3), pp. 773-778. Pennsylvania.
- Hollander, W. F. and Miller, W. J. 1965. Homology of color mutants in two species of ducks. J. of Hered. 56 (6), pp. 295-297. Iowa.
- Holliday, T. A., Asmundson, V. S. and Julian, L. M. 1965. Plasma creatine phosphokinase activity in chickens with hereditary muscular dystrophy. Enzym. Biol. & Clin. 5 (4), p. 209. Calif.
- Holliday, T. A., Van Meter, J. R., Julian, L. M. and Asmundson, V. S. 1965. Electromyography of normal chickens and chickens with inherited muscular dystrophy. Amer. J. Physiol. 209 (5), pp. 871-876. California.
- Jaap, R. George. 1965. Minimum population size and source of stock for gene pools. World's Poul. Sci. J. 21 (2), pp. 172-174. Onio.



Jaffe, W. P. 1965. The relationship between the blood group locus and the intradermal reaction in chickens. Vet. Rec. 77 (14), p. 388. Ohio.

Kinney, T. B., Jr. and Shoffner, R. N. 1965. Heritability estimates and genetic correlations among several traits in a meat-type poultry population. Poul. Sci. 44 (4), pp. 1020-1032. Minnesota.

Landauer, Walter. 1965. Nanomelia, a lethal mutation of the fowl. J. of Hered. 56 (3), pp. 131-138. Connecticut.

Landauer, Walter. 1965. Chondrodystrophy of the fowl. J. of Hered. 56 (5), pp. 209-214. Connecticut.

Larkin, Donna V., Miller, V. L., Bearse, G. E. and Hamilton, C. M. 1965. Effects of starvation and protein depletion on mercury retention in two strains of chickens. Nature 208 (5011), pp. 706-707. Washington.

Law, G. R. J., Miller, W. J., Asmundson, V. S. and Stormont, C. 1965. Blood groups of turkeys. Genetics 51, pp. 253-261. Calif.

Leach, R. M., Jr. and Nesheim, M. C. 1965. Nutritional, genetic and morphological studies of an abnormal cartilage formation in young chicks. J. Nutrition 86 (3), p. 236. New York.

Lewis, K. M. and Blow, W. L. 1965. The effect of genotype-environment interactions on broiler growth. Poul. Sci. 44 (2), pp. 481-486. N. Carolina.

Lowe, P. C., Wilson, S. P. and Harrington, R. B. 1965. Association of some qualitative and quantitative traits in chickens. Poul. Sci. 44 (1), pp. 106-112. Indiana.

Morgan, D. F. and Herrmann, H. 1965. Comparison of muscle tissue from normal and dystrophic chick at different stages of development. Proc. Soc. Exp. Biol. & Med. 120 (1), p. 68. Connecticut.

Omar, E. M., Ferguson, T. M., Creger, C. R. and Couch, J. R. 1965. Enzyme activities in the developing muscle and liver of normal and genetically dystrophic chick embryos. Proc. Soc. Exp. Biol. & Med. 118 (1), pp. 225-227. Texas.

Quigley, George D. 1965. Family differences in attractiveness of poultry to the chicken body louse, Menacanthus stramineus (mallophaga). J. Econ. Entomol. 58 (1), p. 8. Maryland.

Schierman, L. W. 1965. The chicken and recent research in immunology. World's Poul. Sci. J. 21 (1), pp. 6-11. Iowa

Shoffner, R. N. 1965. Current knowledge about the chromosomes in the domestic fowl. World's Poul. Sci. J. 21 (2), pp. 157-165. Minnesota

Siegel, P. B., Phillips, R. E. and Folsom, E. F. Genetic variation in the crow of adult chickens. Behavior 24, pp. 3-4. Va.

Smyth, J. Robert, Jr. 1965. Allelic relationship of genes determining extended black, wild type and brown plumage patterns in the fowl. Poul. Sci. 44 (1), pp. 89-98. Massachusetts

Smyth, J. Robert, Jr. and Somes, Ralph G., Jr. 1965. A new gene determining the columbian feather pattern in the fowl. J. of Hered. 56 (4), pp. 151-156. Massachusetts

Somes, Ralph G. Jr. and Smyth, J. Robert, Jr. 1965. Feather phaeomelanin intensity in Buff Orpington, New Hampshire and Rhode Island Red breeds of fowl. 1. Age, sex and feather growth effects. Poul. Sci. 44 (1), pp. 40-46. Massachusetts

Somes, Ralph G. Jr., and Smyth, J. Robert, Jr. 1965. Feather phaeomelanin intensity in Buff Orpington, New Hampshire and Rhode Island Red breeds of fowl. 2. Inheritance studies from whole feather extracts. Poul. Sci. 44 (1), pp. 47-52. Massachusetts

Somes, Ralph G. Jr. and Smyth, J. Robert, Jr. 1965. Feather phaeomelanin intensity in Buff Orpington, New Hampshire and Rhode Island Red breeds of fowl. 3. Relative quantities of fractionated phaeomelanin pigments. Poul. Sci. 44 (1), pp. 276-282. Mass.

Suzuki, Norio and Kosin, I. L. 1965. An antigenic difference in turkeys following six generations of single-trait selection. J. of Hered. 56 (3), pp. 99-106. Washington

Wilson, Barry W., Peterson, Daniel W. and Lilyblade, Arthur L. 1965. Free amino acids of developing skeletal musculature of normal and genetically dystrophic chickens. Proc. Soc. Exp. Biol. & Med. 119 (1), pp. 104-108. California

Zervas, N. P. and Collins, W. M. 1965. Genetic variation in 14-day chick embryo weight. Poul. Sci. 44 (3), pp. 631-636. New Hampshire



### Selection and Systems of Breeding

Craig, J. V., Ortman, L. L. and Guhl, A. M. 1965. Genetic selection for social dominance ability in chickens. *Animal Behavior* 13 (1), pp. 114-131. Kansas

Krause, Eliot, Yamada, Yukio and Bell, A. E. 1965. Genetic parameters in two populations of chickens under reciprocal recurrent selection. *British Poul. Sci.* 6(3), pp. 197-206. Ind.

Lepore, Paul D., Siegel, P. B. and Siegel, H. S. 1965. Nucleic acid composition of chicks and chick tissues from growth selected lines of White Rocks. *Poul. Sci.* 44 (1), pp. 126-130. Virginia

Nestor, K. E. and Jaap, R. G. 1965. Selection for chick comb weight with androgen and gonadotrophin stimulation. *Poul. Sci.* 44 (6), pp. 1441-1451. Ohio

Siegel, P. B. 1965. Genetics of behavior: Selection for mating ability in chickens. *Genetics* 52 (6), pp. 1269-1277. Virginia

Stephenson, A. B., Kinder, Q. B. and Funk, E. M. 1965. Selection for egg production within crossbred chickens. *Poul. Sci.* 44 (4), pp. 925-936. Missouri

Tindell, D. and Arze, C. G. 1965. Sexual maturity of male chickens selected for mating ability. *Poul. Sci.* 44 (1), pp. 70-72. Georgia

Wearden, S., Tindell, D. and Craig, J. V. 1965. Use of a full diallel cross to estimate general and specific combing ability in chickens. *Poul. Sci.* 44 (4), pp. 1043-1053. Kansas

## AREA NO. 10: POULTRY - PHYSIOLOGY

Problem. Continuing basic research in avian physiology is essential to establish fundamental concepts and to increase the knowledge upon which ultimately must depend the solution of such problems as fertility, hatchability, growth, and egg production. Basic physiological knowledge is necessary also for implementation of the subject matter of other disciplines. In reproductive physiology, for example, the dominant role of the central nervous system is now generally recognized, but much intensive research will be required before we can expect useful knowledge of mechanisms by which the varying actions of external and internal factors are integrated and directed to initiate, maintain, or modify reproductive functions. Many aspects of environmental physiology, of responses to stress, and of growth and development likewise depend upon basic research. On the more immediately practical side, increased knowledge of poultry housing, related equipment, and other management factors is necessary to provide optimal ranges of operational efficiency.

### USDA AND COOPERATIVE PROGRAM

This is a continuing program, mainly on basic aspects of the physiology of avian reproduction, but including also applied studies pertaining to environmental physiology and management. In addition to physiologists, the work draws upon geneticists and animal husbandmen. Research is in progress at Beltsville, Maryland, and Glendale, Arizona; the work at Glendale contributing to regional project W-50. Cooperation currently is maintained with members of the Farm Electrification Branch, AERD; Inspection Branch, Poultry Division, C&MS; the National Institutes of Health; and Pennsylvania State University. Under PL-480, a five-year project (1964-1969) on the effect of growth hormone on fat metabolism in adult hens is in progress at the Agricultural University, Warsaw, Poland. A two-year project (1965-1967) was initiated with the National and University Institute of Agriculture, Rehovoth, Israel, for studies on the effectiveness of selection and various artificial insemination techniques in increasing the fertility of chickens inseminated with turkey semen.

A total of 4.0 scientific man-years is devoted to this program annually. The entire effort is in physiology of reproduction.

### PROGRAM OF STATE EXPERIMENT STATIONS

The total research effort on poultry physiology by State agricultural experiment stations is 44.8 scientific man-years.



PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Physiology of Reproduction

1. Neuroendocrinology. Previous studies have shown that surgical removal of the neural lobe of the pituitary gland does not prevent or delay oviposition in the chicken. Further experiments were designed to test the possibility that, in neural lobectomized hens, oviposition might be caused by regulated release of neurohypophyseal hormones from a more proximal region of the neurohypophysis. Neural lobectomy was performed in 130 hens on the day before expected lay of the terminal ( $C_t$ ) egg of a 2-egg sequence. Extracts of the stalk-median eminence region of the neurohypophysis, or of jugular venous plasma, taken from lobectomized hens before, during or after normally occurring  $C_t$  lay, or premature  $C_t$  lay induced by brain pique, were assayed for arginine vasotocin and oxytocin by the frog bladder and rat uterine methods. Both normal and induced  $C_t$  lay in lobectomized hens were associated with a significant loss of an arginine vasotocin-like activity from stalk-median eminence tissue and a marked increase in this activity in plasma. Preliminary histological studies indicate a heavy accumulation of neurosecretory material in the pituitary stalk before lay, followed by a marked depletion of this material during lay. These findings suggest that oviposition in neural lobectomized hens results from the abrupt release of arginine vasotocin from the proximal neurohypophysis and strongly support evidence by other workers that arginine vasotocin is the oviposition-inducing hormone in birds.

The neuroendocrine control of ovulation in birds, as in mammals, is thought to depend on the existence of a humoral substance produced and stored in the hypothalamus and periodically released into the portal circulation where it is transported to the adenohypophysis to effect the release of ovulating hormone. Preliminary studies with crude hypothalamic extracts tend to verify the existence of such a releasing factor in the chicken. Ovulations have been induced by slow infusion of the extracts directly into the adenohypophysis of the chicken or into the jugular vein of the Coturnix quail.

Centrally active drugs such as dibenamine or atropine have been found to be fairly effective in blocking ovulation in chickens. Under a 14-hour light-day, the drugs are most effective when applied at 8 to 14 hours before ovulation. This period is thought to represent the interval during which a neurogenic stimulus from the brain elicits the release of pituitary ovulating hormone. Several nerve blocking agents were screened in Coturnix quail, which ovulate in sequences superficially similar to those of the chicken, with the major difference that Coturnix ovulate most of their eggs in the last - rather than in the first one-half of the standard light-day. As in the chicken, dibenamine was found to be the most effective blocking agent, preventing ovulation in about 60% of the quail when given at 10-12 hours before ovulation. All drugs tested were ineffective when given at



4 hours before ovulation. A commercially available anesthetic containing chloral hydrate, pentobarbital and magnesium sulfate was later found to be completely effective in blocking ovulation in Coturnix when given at 10-12 hours before ovulation. The active ingredient(s) has not yet been defined. The discovery of a completely effective blocking agent in quail should greatly facilitate studies of the neuroendocrine control of ovulation in this species. (AH e3-21)

2. Parthenogenetic reproduction. Studies were undertaken to obtain additional evidence that segregation and replication of chromosomes do occur in germ cells that give rise to turkey parthenogens. Data were obtained through the use of a genetically controlled plumage color marker. Beltsville Small White hens of the parthenogenetic strain were mated to homozygous bronze males to obtain heterozygous bronze females. Unfertilized eggs from these heterozygous bronze females were incubated. A total of 33 parthenogenetic embryos (16 days or older) and poults were obtained from eggs of these hens, 16 of which were white and 17 bronze colored. These data showed that maternal and paternal chromosomes were segregating as would be expected.

Four parthenogens (three bronze and one white) reached sexual maturity, and each was subsequently mated (artificial insemination) to virgin Beltsville Small White females. A total of 66 poults were sired by the white parthenogen, all of which had white down. A total of two hundred thirty-three poults were sired by two of the bronze parthenogens, all of which had bronze color markings. These data show that all three parthenogens were homozygous, two for the dominant bronze factor, and one for the recessive factor responsible for absence of color.

The third bronze parthenogen, on being mated to Beltsville Small White hens, sired 167 poults and advanced embryos, 59 of which were white and 78 bronze. These results show that this particular bronze parthenogen was heterozygous for the bronze factor. Heterozygosity in this instance probably came about as a result of a crossover involving the locus for color and occurring just prior to meiosis I. Wattle skin from this heterozygous bronze parthenogen, upon being grafted to the saddle region of his heterozygous dam, survived permanently, proving that no pedigree error had been made and that the male was without doubt of parthenogenetic origin.

A histological study was made of blastodiscs of unfertilized turkey eggs to obtain more precise information on reasons for the characteristic 2-3 day delay in onset of parthenogenetic development. Blastodiscs were removed from unfertilized eggs prior to and at 24-hour intervals during the first four days of incubation. This study revealed that cells in discs of unfertilized eggs at time of lay were for the most part highly unorganized. Cells tended to form in multiple layers and failed to give rise to a segmentation cavity. Many of the cells appeared to be moribund or dead, and numerous vacuoles appeared throughout the protoplasmic disc. This same



atypical arrangement of early blastomeres was observed in sections of germinal discs removed from eggs incubated for 24, 48, 72, and 96 hours. In some discs, newly formed layers of small epithelial type cells were observed at 48 hours of incubation at the upper surface of the discs and just beneath the vitelline membrane. This study revealed the fact that some but not all of the large blastomeres present in the discs of unfertilized eggs at time of oviposition gave rise to the smaller epithelial type cells. It is concluded that the characteristic time lag of 2-3 days observed in the onset of parthenogenetic development probably represents the time required for certain of the more viable blastomeres in the unorganized disc to resume development and to organize a normal type of blastoderm. (AH e3-19)

3. Eggshell pigmentation in Japanese quail. Last year it was reported that oöporphyrin is the principal pigment found on the eggshell and in the uterus of wild-type and mutant white-egg quail hens and that the oöporphyrin content of the wild-type uterus is greatly reduced following deposition of the superficial eggshell pigment, i.e., between the second and third hours prior to oviposition. Continuing this line of work, 3N HCl extracts were prepared of mutant uteri before and after the time of expected superficial eggshell pigment deposition. The optical densities (O.D.) of these extracts were determined spectrophotometrically at 410 mμ - the wavelength of light specifically absorbed by oöporphyrin under these conditions. These O.D. values for mutant extracts were then compared with identically obtained values for wild-type extracts. The mean optical densities for mutant uterine extracts were 0.420 and 0.365, respectively, before and after superficial pigment deposition. In comparison the mean O.D. values for wild-type extracts were 1.120 and 0.506, respectively. These data indicate the oöporphyrin content of mutant uteri is lower than wild-type uteri, and that it is significantly reduced at the same time superficial pigment is deposited on the eggshell. Accordingly, the mutant phenotype is not the result of an abnormal retention of pigment by the uterus but, more likely, is based on an inability of the mutant hen to form adequate quantities of oöporphyrin for normal shell pigmentation.

The ability of wild-type and mutant quail uteri to form oöporphyrin from its precursor, delta-aminolevulinic acid (ALA), was compared as follows. Pairs of hens, one of each type, were selected so that within pairs both hens were expected to lay within the same hour. All were killed 3-6 hours before expected oviposition. One gram of uterine tissue from each hen was homogenized in cold buffered saline and centrifuged. Equal aliquots of supernate from each hen's homogenate were incubated 20 hrs. at 41°C with 0.08, 0.175, 0.35, and 0.7 ml. of 0.008 M ALA in buffered saline. A control tube containing homogenate but no ALA was included for each hen. Following incubation, HCl extracts were prepared of each homogenate and the O.D. curve of each was determined spectrophotometrically between wavelengths 360-480 mμ. Under these conditions oöporphyrin is indicated by a strong absorption peak at 407-408 mμ. The only absorption peak in each homogenate + ALA tube occurred at 407-408 mμ. The mean O.D. values of wild-type homogenates at the



four ALA levels concerned were: 0.269, 0.393, 0.448, and 0.483; while similar values for mutant homogenates were 0.199, 0.270, 0.298, and 0.307. They show a positive correlation of the O.D. with the amount of ALA available to the homogenates of both quail phenotypes. More importantly, they show that at each ALA level the mean O.D. of mutant homogenates is much lower than that of wild-type homogenates. They are interpreted as evidence that mutant uterine homogenates are not capable of synthesizing as much oöporphyrin in vitro from ALA as wild-type homogenates. They suggest that the basis of the mutant quail phenotype is a reduced ability in the uterus to synthesize oöporphyrin from its precursors.

The quail findings are of further interest when compared with previous extramural research showing that uterine homogenates from brown-egg and white-egg chickens were equal in their capacity for in vitro synthesis of oöporphyrin from ALA. The chicken data suggested that ALA, or one of its precursors, was limiting in uterine tissue of white-egg chickens. The quail data do not conform to this idea even though mutant homogenates were capable of some oöporphyrin synthesis. At lower ALA levels there was a limitation on the amount of oöporphyrin synthesized by homogenates from both quail phenotypes. At the highest ALA level, however, the limiting effect was greatly diminished. It is hard to see how additional ALA supplied to mutant homogenates could have caused them to synthesize an amount of oöporphyrin equal to wild-type homogenates. Thus, it appears, there is a fundamental difference between white-egg quail and white-egg chickens in the physiological mechanism determining eggshell pigmentation. This is not unexpected in view of the fact that genetic control of the trait is also quite different in the two species. (AH e3-25)

## B. Environmental Physiology

1. Effect of light intensity on egg production. In an experiment on October-hatched White Leghorn females, starting at day-old, four different lighting schedules were used. The schedules were: (1) daylight only through first 20 weeks, then 16 hours light daily, (2) a total of 16 hours light daily throughout the experiment, (3) 24 hours light daily at the start, decreased gradually until about the same as daylight, then increased gradually to 24 hours, (4) daylight only first 12 weeks, then follow schedule 3. The only significant difference has been in favor of larger egg size for birds under a step-down - step-up light pattern (schedules 3 and 4). The greatest difference was on schedule 3.

In a repeat experiment, White Leghorn pullets hatched in March were given 16 hours light daily during one year of lay. Supplemental light for all pullets was from 40-watt bulbs until they were 20 weeks old, and thereafter the supplemental light for duplicate groups was from 15, 40, 300, 500, or 1000 watt bulbs. The different supplemental light intensities had little effect on egg production, except that egg production was appreciably higher one year and lower the next with the 1000 watt bulbs. (AH e3-23)



2. Light intensity and cannibalism. In a study of the effect of dim light on cannibalism among layers in colony cages (24" x 18" cages, five birds per cage), 100 White Leghorns were in a "closed" house (walls of wood and no windows) and 100 were in an "open" house (walls of wood lath). All light was supplied by 15 watt bulbs in the "closed" house and by daylight plus supplemental light from 40 watt bulbs in the "open" house. All birds received a total of 16 hours light daily. All birds were debeaked prior to housing. Deaths from cannibalism accounted for 6% of the birds in the "open" house and none in the "closed" house. The "closed" house was cooled with an evaporative cooler and the "open" house with foggers. Three days' eggs were taken during every 28-day period and checked for Haugh units, blood spots, shell weight and thickness. In the "closed" house the eggs had slightly heavier shells during the hot months. No difference in Haugh units were observed. Egg production was greater in the "closed" house. (AH e3-24)

#### PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

##### Physiology of Reproduction

- Olsen, M. W. 1965. Delayed development and atypical cellular organization in blastodiscs of unfertilized turkey eggs. *Develop. Biol.* 12, 1-14. (AH e3-19)
- Olsen, M. W. 1966. Frequency of parthenogenesis in chicken eggs. *J. Hered.* 57, 23-25. (AH e3-19)
- Opel, H. 1966. Release of oviposition-inducing factor from the median eminence-pituitary stalk region in neural lobectomized hens. *Anat. Rec.* 154, 396 (Abs.). (AH e3-21)
- Opel, H. 1966. The timing of oviposition and ovulation in the quail (*Coturnix coturnix japonica*). *British Poultry Sci.* 7, 29-38. (AH e3-22)
- Opel, H. 1966. A simple cannula for implantation into the chicken brain. *Poultry Sci.* 45, 856-858. (AH e3-21)
- Opel, H. 1966. Effects of neuro- and adeno-hypophysectomy on the hypothalamo-hypophyseal system of the chicken. *Am. Zool.* 6, 312 (Abs.). (AH e3-21)
- Poole, H. K. 1966. Relative oöporphyrin content and porphyrin forming capacity of wild-type and white-egg Japanese quail uterine tissue. *Proc. Soc. Exptl. Biol. and Med.* 122, 596-598. (AH e3-25)

##### Environmental Physiology

- Marsden, S. J., Lucas, L. M., and Wilson, S. P. 1966. The influence of daylength and environment on reproduction, broodiness, and mortality of turkeys. *Poultry Sci.* 45, 668-675. (AH e3-18)

## Related Publications of State Experiment Stations

### Physiology of Reproduction

- Adams, Eugene V. 1965. Monolayer growth of chicken neuroglial cells in tissue culture. Poul. Sci. 44 (6), pp.1558-1561. New Jersey.
- Arscott, G. H., Parker, J. E. and Dickinson, E. M. 1965. Effect of dietary linoleic acid, vitamin E and ethoxyquin on fertility of male chickens. J. Nutrition 87 (1), pp. 63-68. Oregon.
- Bell, D. J. and Sturkie, Paul D. 1965. Chemical constituents of blood. Chapter 2, pp.32-84, Avian Physiology (Second Edition) Comstock Publishing Associates, Cornell Univ. Press, Ithaca, New York. N. J.
- Bobr, L. W., Lake, P. E., Lorenz, F. W., Ogasawara, F. X. and Krzanowska, H. 1965. Inhibition of ovulation in the domestic hen by intrauterine insemination. Poul. Sci. 44 (3), pp. 659-661. Calif.
- Boone, M. A. and Barnett, B. D. 1965. The effect of nidroxyzone and nihydrazone on laying hens. Poul. Sci. 44 (2), pp. 514-519. S. C.
- Bray, D. J., Jennings, R. C. and Morris, T. R. 1965. The effects of early and late maturity on the protein requirements of pullets. British Poul. Sci. 6 (4), pp. 311-319. Illinois.
- Frankel, A. I., Gibson, W. R., Graber, J. W., Nelson, D. M., Reichert, L. E., Jr. and Nalbandov, A. V. 1965. An ovarian ascorbic acid depleting factor in the plasma of adenohipophysectomised cockerels. Endocrinology 77 (4), p. 651. Illinois.
- Giri, S. N. and Peoples, S. A. 1965. Renal and hepatic effects on potency of testosterone propionate in chicken. Proc. Soc. Exp. Biol. & Med. 120 (2), p. 523. California.
- Graber, Jean W. and Nalbandov, A. V. 1965. Neurosecretion in the White Leghorn cockerel. Gen. & Comp. Endocrinol. 5 (5), p. 485. Illinois.
- Grimes, G. R. and Moreng, R. E. 1965. The effect of hygromycin B on the reproductive performance of two breeds of laying hens. Poul. Sci. 44 (3), pp. 748-753. Colorado.



- Hammond, Mary, Boone, M. A. and Barnett, B. D. 1965. Study of the glucose, electrolytes, enzymes and nitrogen components of fowl seminal plasma. J. Reprod. Fertil. 10 (1), pp. 21-28. S. C.
- Harper, J. A. 1965. Fertility of turkey eggs as related to method of collecting and aeration of semen. Poul. Sci. 44 (3), pp. 726-731. Oregon.
- Kemmerer, A. R., Heywang, B. W., Vavich, M. G. and Sheehan, E. T. 1965. Effect of cottonseed oil on egg hatchability. Poul. Sci. 44 (5), pp. 1315-1318. Arizona.
- King, John E., Ackerman, G. Adolph and Knouff, Ralph A. 1965. The effect of testosterone on the morphogenesis of the chick thymus. Anat. Rec. 151 (1), p. 11. Ohio.
- Kosin, I. L. and Mun, A. M. 1965. Some factors affecting the biological quality of turkey hatching eggs. Poul. Sci. 44 (1), pp. 31-39. Washington.
- Nelson, D. M., Norton, H. W. and Nalbandov, A. V. 1965. Hypophysial and plasma LH levels in intact and castrate cockerels. Endocrinology 77 (4), p. 731. Illinois.
- Nelson, D. M., Norton, H. W. and Nalbandov, A. V. 1965. Changes in hypophysial and plasma LH levels during the laying cycle of the hen. Endocrinology 77 (5), p. 889. Illinois.
- Parker, J. E. and McCluskey, W. H. 1965. The effect of length of daily light periods on sexual development and subsequent fertilizing capacity of male chickens. Poul. Sci. 44 (1), pp. 23-27. Oregon.
- Parker, J. E. 1965. Semen production of cockerels as related to their subsequent capacity to fertilize hens in flock matings. Poul. Sci. 44 (2), pp. 474-477. Oregon.
- Patrick, H., Voitle, H. A., Hyre, H. M. and Martin, W. G. 1965. Incorporation of phosphorus and selenium in cock sperm. Poul. Sci. 44 (2), pp. 587-591. W. Va.
- Reid, B. L., Heywang, B. W., Kurnick, A. A., Vavich, M. G. and Hulett, B. J. 1965. Effect of vitamin A and ambient temperature on reproductive performance of White Leghorns. Poul. Sci. 44 (2), pp. 446-452. Arizona.

- Ringer, Robert K. 1965. Thyroids - Chapter 19, pp. 592-648. Avian Physiology (Second Edition), Comstock Publishing Associates, Cornell Univ. Press, Ithaca, New York. Michigan.
- Sato, Koji and Glick, Bruce. 1965. Reduction of anaphylactic shock in bursectomized chickens. Nature 205 (4971), p. 612. Mississippi.
- Sato, Koji and Glick, Bruce. 1965. Anaphylactoid response induced by a single injection of the bursa of Fabricius. Poul. Sci. 44 (6), pp. 1572-1580. Mississippi.
- Siegel, H. S. and Mraz, F. R. 1965.  $I^{131}$  Uptake in radiothyroidectomized chicks. Poul. Sci. 44 (3), pp. 785-788. Virginia.
- Simpson, C. F., Harms, R. H. and Damron, B. L. 1965. Failure of reserpine to modify the incidence of aortic ruptures induced in turkeys by diethylstilbestrol. C. R. Soc. Biol. & Med. 120 (2), p. 321. Fla.
- Simpson, C. F. and Harms, R. H. 1965. Relationship of age and sex of turkeys to aortic ruptures induced by diethylstilbestrol. Proc. Soc. Exp. Biol. & Med. 119 (2), p. 509. Florida.
- Simpson, C. F., Harms, R. H. and Wilson, H. R. 1965. Alteration of sex characteristics of turkey poults with diethylstilbestrol. Proc. Soc. Exp. Biol. & Med. 119 (2), p. 435. Florida.
- Singsen, E. P., Nagel, Jobst, Patrick, S. G. and Matterson, L. D. 1965. The effect of a lysine deficiency on growth characteristics, age at sexual maturity, and reproductive performance of meat-type pullets. Poul. Sci. 44 (6), pp. 1467-1473. Connecticut.
- Snedecor, James G. and Mellen, William. 1965. Thyroid deprivation and replacement in chickens. Poul. Sci. 44 (2), pp. 452-459. Mass.
- Turk, D. E. 1965. Effects of diet on the tissue zinc distribution and reproduction in the fowl. Poul. Sci. 44 (1), pp. 122-126. S. C.
- Verma, O. P. and Cherms, F. L. 1965. The appearance of sperm and their persistency in storage tubules of turkey hens after a single insemination. Poul. Sci. 44 (2), pp. 609-613. Wisconsin.
- Williamson, J. H. 1965. Cystic remnants of the right Mullerian duct and egg production in two strains of White Leghorns. Poul. Sci. 44 (2), 321-324. New York.
- Wilson, H. R., Waldroup, P.W., Jones, J.E., Duerre, D.J. and Harms, R.H. 1965. Protein levels in growing diets and reproductive performance of cockerels. J. Nutrition. 85 (1), p. 29. Florida.



Environmental Physiology

- Adler, H. E. and Sadler, W. W. 1965. Response of the turkey to Mycoplasma gallisepticum infection. Poul. Sci 44 (1), pp. 136-140. California.
- Ball, R. A., Sauter, J. H., Pomeroy, B. S. and Waibel, P. E. 1965. Natural and experimental dissecting aneurysms in turkeys. J. Pathol. & Bacteriol. 89 (2), p. 599. Minnesota.
- Besch, E. L., Smith, A. H. and Goren, S. 1965. Effect of accelerative forces on avian embryogenesis. J. Appl. Physiol. 20 (6), p. 1232. California.
- Besch, E. L., Smith, A. H. and Walker, M. W. 1965. Morphological changes in avian eggs subjected to accelerative force. J. Appl. Physiol. 20 (6), p. 1241. California.
- Brambila, S. and Hill, F. W. 1965. Paralysis induced by feeding synthetic glycerides to chicks. Proc. Soc. Exp. Biol. & Med. 118 (3), p. 845. California.
- Cardona, Nestor A., Hartsook, E. W. and Boucher, R. V. 1965. Influence of kinetic factors on renal xanthine dehydrogenase activity in chicken tissue. Poul. Sci. 44 (5), pp. 1164-1173. Pennsylvania.
- Carmon, Louie G. and Huston, Till M. 1965. The influence of environmental temperature upon egg components of domestic fowl. Poul. Sci. 44 (5), pp. 1237-1240. Georgia.
- Cole, John R., Jr. and Boyd, Frank M. 1965. Serum protein and amino acid levels of Escherichia coli-infected chicks on high and low levels of dietary protein. Poul. Sci. 44 (6), pp. 1580-1582. Georgia.
- Filson, D. R., Weiser, H. H., Meredith, W. E. and Winter, A. R. 1965. Absorption of chlortetracycline from the alimentary tract in White Leghorn hens. Poul. Sci. 44 (3), pp. 761-767. Ohio.
- Fisher, Hans and Griminger, P. 1965. Restricted protein intake and avian atherosclerosis. Nature 207 (4994), p. 329. New Jersey.
- Francis, D. W., Roberson, R. H. and Finkner, M. D. 1965. The effect of fowl pox vaccination, strain and sex on several glands or organs of White Leghorn chickens. Avian Diseases 9 (1), pp. 146-151. New Mexico.

- Frankel, H. M. 1965. Blood lactate and pyruvate and evidence for hypocapnic lacticacidosis in the chicken. Proc. Soc. Exp. Biol. & Med. 119 (1), p. 261. Illinois.
- Grau, C. R., Austic, R. E. and Matteson, G. C. 1965. Degeneration of the eyes of tyrosine-deficient chick embryos. Science 148, pp. 1743-1745. California.
- Grau, C. R., Wilson, B. W. and Matteson, G. C. 1965. Relation of oxygen and yolk to retinal pigmentation in chick embryos subjected to yolk-sac perfusion. Proc. Soc. Exp. Biol. & Med. 119, pp. 544-547. California.
- Gross, W. B. and Siegel, H. S. 1965. The effect of social stress on resistance to infection with Escherichia coli or Mycoplasma gallisepticum. Poul. Sci. 44 (4), pp. 998-1001. Virginia.
- Heatley, N. G., McElheny, F. and Lepkovsky, S. 1965. Measurement of the rate of flow of pancreatic secretion in the anesthetized chicken. Comp. Biochem. Physiol. 16, pp. 29-36. California.
- Huston, Till M. 1965. The influence of different environmental temperatures on immature fowl. Poul. Sci. 44 (4), pp. 1032-1036. Georgia.
- Imondi, A. R. and Bird, F. H. 1965. The sites of nitrogen absorption from the alimentary tract of the chicken. Poul. Sci. 44 (4), pp. 916-920. Maine.
- Kare, M. R. 1965. The special senses - Chapter 14, pp. 406-446. Avian Physiology (Second Edition) Comstock Publishing Associates, Cornell Univ. Press, Ithaca, New York. N. Carolina.
- Lauber, Jean, K., McGinnis, James and Boyd, James. 1965. Influence of miotics, diamox and vision occluders on light-induced buphthalmos in domestic fowl. Soc. Exp. Biol. & Med. 20, pp. 572-575. Washington.
- Lepkovsky, S., Furuta, F., Koike, T., Hasegawa, N., Dimick, M. K., Krause, K. and Barnes, F. J. 1965. The effect of raw soybeans upon the digestion of proteins and upon the function of the pancreas of intact chickens and of chickens with ileostomies. Brit. J. Nutr. 19, pp. 41-56. California.



- Lepkovsky, S., Len, R., Koike, T. and Bouthilet, R. 1965. Effects of protamine zinc insulin on chickens. Am. J. Physiol. 208 (3), pp. 589-592. California.
- McGinnis, Charles H., Jr. and Ringer, Robert K. 1965. Cartoid and vertebral artery ligation in the chicken. Poul. Sci. 44 (6), pp. 1600-1603. Michigan.
- Mraz, F. R. 1965. Radioisotopes and poultry. World's Poul. Sci. J. 21 (3), pp. 238-261. Tennessee.
- Prince, R. P., Whitaker, J. H., Matterson, L. D. and Luginbuhl, R. E. 1965. Response of chickens to temperature and relative humidity environments. Poul. Sci. 44 (1), pp. 73-77. Connecticut.
- Roberson, R. H. and Frnacis, D. W. 1965. Anatomical development of White Chinese geese. Poul. Sci. 44 (3), pp. 835-839. N. Mexico.
- Ryan, C. A. 1965. Chicken chymotrypsin and turkey trypsin. Part I: Purification. Arch. Biochem. Biophys. 110 (1), p. 169. Washington.
- Ryan, C. A., Clary, John J. and Tomitsu, Y. 1965. Chicken chymotrypsin and turkey trypsin. Part II: Physical and enzymatic properties. Arch. Biochem. Biophys. 110 (1), p. 175. Washington.
- Schein, M. W. and Hale, E. B. 1965. Stimuli eliciting sexual behavior. In F. A. Beach (Ed) Sex and Behavior, New York Wiley, pp. 440-482. Pennsylvania.
- Scholes, Norman W. 1965. Effects of parenterally administered gamma-aminobutyric acid on the general behavior of the young chick. Life Sci. 4 (20), 1945. California.
- Siegel, H. S. and Gross, W. B. 1965. Social grouping stress and resistance to coliform infection in cockerels. Poul. Sci. 44 (6), pp. 1530-1536. Virginia.
- Smith, A. H. and Kelly, C. F. 1965. Biological effects of chronic acceleration. Naval Research Reviews, Nov. pp. 1-11. Office of Naval Research, Department of the Navy, Washington, D. C. Calif.
- Starcher, Barry and Hill, Charles H. 1965. Hormonal induction of ceruloplasmin in chicken serum. Comp. Biochem. Physiol. 15, pp. 429-434. N. Carolina.

- Sturkie, P. D. 1965. Avian Physiology - Second Edition  
Comstock Publishing Associates, Cornell Univ. Press, Ithaca,  
New York. New Jersey.
- Sturkie, P. D., Whittow, G. C. and Eiel, J. M. 1965.  
Cardiovascular responses of chickens to high and low ambient  
temperatures. 23rd Internat. Cong. of Physiol. Sciences,  
Tokyo. New Jersey.
- Sullivan, T. W. 1965. Hemoglobin, white cell count, packed  
cell volume and weight gain in turkeys fed certain antibiotics.  
Proc. Soc. Exp. Biol. & Med. 119 (3), p. 731. Nebraska.
- Taylor, Lewis W. and Kreutziger, G. Oscar. 1965. The gaseous  
environment of the chick embryo in relation to its development  
and hatchability. 2. Effect of carbon dioxide and oxygen levels  
during the period of the fifth through the eighth day of incubation.  
Poul. Sci. 44 (1), pp. 98-106. California.
- Waldroup, P. W., Harms, R. H. and Fried, M. 1965. Alterations  
in the serum protein components of laying hens on low protein  
diets. Poul. Sci. 44 (1), pp. 213-215. Florida.
- Whittow, G. C., Sturkie, P. D. and Stein, G., Jr. 1965.  
Cardiovascular changes in restrained chickens. Poul. Sci. 44  
(6), pp. 1452-1459. New Jersey.
- Yamamoto, R., Ortmayer, H. B., Bigland, C. H. and Seely, M. L.  
1965. Isolation of "N" Mycoplasma from different sites of the  
turkey. Poul. Sci. 44 (3), pp. 732-736. California.
- Wessels, J. P. H. and Fisher, Hans. 1965. Estimation of protein  
reserves and the nitrogen content of organs in protein-depleted and  
repleted cocks. Brit. J. Nutrition 19 (1), p. 57. New Jersey.



## AREA NO. 11: POULTRY - NUTRITION

Problem. The goal of nutrition research is to amass information so that poultry diets may be formulated and fed to produce the best quality product at the least possible cost. The problem logically divides into two areas: (1) furnishing the nutritive requirements of poultry, and (2) the feedstuffs that supply these requirements. A refined methodology is needed to estimate more accurately the energy (carbohydrates and fats), protein (amino acids), vitamin and mineral requirements of poultry of various ages, strains, and levels of production. Even more urgently needed is information on the relationships that exist between these nutrients, if the formulation of optimum nutritive balance in diets is to be attained. Additional information is required on the effect of feed additives (antibiotics, arsenicals, hormones, enzymes, antioxidants, tranquilizers) on nutritive requirements, and on the utilization of protein and energy. Somewhere in the maze of requirements, interrelationships, and interactions, it must be determined which portion of the diet is for intestinal micro-organisms, and which is for the host. Also, the vast field of interrelationships between disease and nutrition remains to be explored. In the feedstuffs area, how much of a particular nutrient that is present should be known, but of more importance is how much is available to the bird. Thus, information on digestibility, absorption, chelation, and interactions is necessary. In addition, the complete composition of a feedstuff must be known. At the present, the proximate analysis is the only information available about major dietary constituents; consequently, the nutritionist does not know exactly what is being fed when a diet is formulated. Growth promotants and/or inhibitors which he is not aware of may be present.

## USDA AND COOPERATIVE PROGRAM

This is a continuing program conducted by nutritionists on basic and applied research on the nutritive requirements, digestion and metabolism of poultry, and the nutritive value of feedstuffs. The work is in progress at Beltsville, Maryland, and at the Southwest Poultry Experiment Station, Glendale, Arizona. Some phases of work at Glendale are carried on in cooperation with the Departments of Biochemistry and Poultry Science of the University of Arizona at Tucson.

Research contracts are in effect with Iowa State University, Ames, Iowa, (three years, 1965-1968) to study malathion residues in poultry meat and eggs, and with the University of Georgia, Athens, Georgia, (three years, 1966-1969) to investigate procedures to accelerate the elimination of DDT residues from eggs and body tissues of hens.

Public Law-480 projects are in progress or have been initiated as follows:

- (1) A project concerned with the influence of different factors on

metabolism of vitamin A in chickens at the Hebrew University, Rehovot, Israel, (five years, 1962-1967); (2) a project for the evaluation of the protein quality and energy values of feedstuffs available in India, at Punjab Agricultural University, Ludhiana, India, (five years, 1964-1969), and (3) an investigation of calcium and phosphorus metabolism in chickens and factors influencing shell quality at the National University, Rehovot, Israel, (five years, 1964-1969).

The Federal effort devoted to research in poultry nutrition totals 5.0 scientific man-years. Of this number 3.0 are devoted to digestion and metabolism, 1.5 to nutritive values of feeds, and 0.5 to nutritive requirements.

#### PROGRAM OF STATE EXPERIMENT STATIONS

The total research effort on poultry nutrition by State agricultural experiment stations is 70.6 scientific man-years.

#### PROGRESS -- USDA AND COOPERATIVE PROGRAMS

##### A. Nutritive Requirements

Requirements of essential fatty acids. In continued studies on essential fatty acid requirement for laying hens, it was found that the performance on a purified, fat-free basal diet (cerelose, casein-gelatin, minerals and vitamins) supplemented with 4% linoleic acid did not equal that of a practical diet. Since the poorer performance was not due to decreased feed consumption, some type of dietary deficiency was indicated. Tests of various formulations showed that where purified soy protein was substituted for casein-gelatin in the fat-free diet, the performance equaled that of the practical diet. Purified soy protein diets will be used in future work.

In studies to determine the linoleic acid requirement of growing chickens, specially designed low-fat practical diets were used to avoid the difficulty encountered with the purified diets in laying hen work. Since the chick's requirement for linoleic acid is minimal, and body reserves carried over from the egg are utilized so efficiently, the requirement could not be pinpointed using the practical diets.

Other studies indicated that severe depletion caused damage that could not be overcome by linoleic acid supplementation. The body weights of depleted chicks fed a practical diet containing 4% linoleic acid were smaller than those of nondepleted chicks fed the same diet. This difference persisted up to 16 weeks of age. (AH e2-20)

##### B. Digestion and Metabolism

1. Metabolism of fats. Studies to investigate further the role of linoleic acid in hatchability showed that linoleic acid deficient embryos



were most severely affected during the early and late stages of incubation. The mortality which occurred during these periods was much greater in the deficient eggs than in control eggs from hens on a linoleic acid replete diet. The total mortality was 56% in the deficient eggs, as compared with 10% in the controls. In the deficient eggs, 85% of all living embryos were in a malposition at 21 days of incubation, as compared with 10% malpositions in the control groups. When the deficient eggs were kept in the incubator for 28 days, an additional 1 to 2% of the fertile eggs hatched.

Oxygen consumption of embryos from 14 to 21 days of incubation was measured. It was lower in the linoleic acid deficient embryos than in normal embryos. This may be indicative of a lowered metabolic rate. In general, it appears that linoleic acid deficiency caused a delay in embryonic development which was fatal to a high percentage of the embryos.

In other studies a technique was developed whereby as much as 1.5 ml of yolk could be withdrawn from an egg after four days of incubation, and replaced by an equal quantity of yolk from another egg. Using this technique, the hatchability of linoleic acid deficient embryos was increased from 0 to 12% by injecting 1 ml. of egg yolk from hens receiving 3% of dietary linoleic acid into yolks from hens deficient in this fatty acid. When pure linoleic acid was injected into the yolk all embryos died. (AH e2-20)

2. Metabolism of calcium. Studies on the metabolism of calcium in the laying hen were continued at the National University, Rehovot, Israel. In isocaloric diets, when calcium carbonate was varied at the expense of insoluble grit, high calcium levels (4.5 percent) in high-fiber diets reduced egg weight. In all diets, there was a tendency for reduced egg production and a decrease in gain in body weight when high levels of calcium were fed. High dietary calcium reduced feed consumption only in rations that contained high levels of fat. (A10-AH-20)

3. Utilization and function of vitamin A. Continuing studies with vitamin A at the Hebrew University, Rehovot, Israel, have shown that carotenoids play a role in the biogenesis of vitamin A<sub>2</sub> in fresh-water fish. When two species of aquarium fish received anhydrolutein, there was an increase in vitamin A<sub>2</sub> in the fish, whereas vitamin A<sub>1</sub> remained unchanged. Beta-carotene was converted to a mixture of vitamin A<sub>1</sub> and A<sub>2</sub>, in which the former predominated. Astaxanthin, canthaxanthin, and isozeaxanthin gave results similar to those obtained with beta-carotene. Lutein was inactive as a vitamin A precursor. These results indicate that fresh-water fish are able to utilize 4-keto-beta-carotenoids for conversion to both vitamin A<sub>1</sub> and A<sub>2</sub>. This is in contrast to previous results which showed that chicks and mice cannot form vitamin A<sub>2</sub> in the absence of dietary precursors containing a 3, 4-dehydro-beta-ionone ring.



Other studies have shown that high ambient temperatures act like high dietary protein levels or dietary thyroxine supplementation in increasing the hepatic vitamin A alcohol fraction at the expense of the ester fraction. This suggests a relationship between the proportion of hepatic vitamin A alcohol and the level of vitamin A metabolism. (A10-AH-7)

### C. Nutritive value of Feeds

1. Effects of feeding cottonseed meal. Tests were conducted at Glendale, in cooperation with the University of Arizona, on the effect of dietary cottonseed oil on hatchability. Crude gossypol-free cottonseed oil, fed to laying hens at levels of 2 and 5%, significantly lowered hatchability of the eggs. Dietary levels of 0.5 and 1.0%, which encompass the range of practical-type rations, did not affect hatchability. Sterculia foetida oil, fed at a level to give an amount of cyclopropenoid fatty acid equivalent to 5% crude cottonseed oil, also lowered hatchability.

Other studies at Glendale, in cooperation with the University of Arizona, were conducted to compare the effect of glanded and glandless cottonseed meal on egg discoloration. Pink whites were found only in eggs, stored for 6 months, from layers fed diets containing glanded cottonseed meal. When glanded cottonseed meal replaced all the soybean meal in the diet, practically no eggs were discolored after storage of one month, but most of the eggs were discolored after storage of 3 or 6 months. When glandless cottonseed meal replaced soybean meal, only a few yolks were discolored after 6 months of storage. The dietary treatments had no other effects on performance of eggshell quality. (AH e2-17 Rev.)

2. Antibiotics and egg production. In tests conducted at Glendale, the effect of antibiotics on layer performance of strains of good and poor layers, in hot and cool weather was investigated. No supplement had an appreciable effect on the performance of high-producing White Leghorns or Rhode Island Reds during either hot or cool weather. All supplements improved the egg production of a poor-egg-producing, high-mortality strain of White Leghorns during cool weather in one test and during hot weather in two tests. The supplements had no consistent effect on feed consumption, feed efficiency, body weight, egg weight, or hatchability of fertile eggs.

Tranquilizers and egg production. Studies of the effect of reserpine on laying hen performance conducted at Glendale showed that the tranquilizer had no consistent stimulating effect on egg production of either older or younger hens. Feed consumption, feed efficiency, body weight, body temperature, or shell quality were not affected by the tranquilizers. (AH e2-15 Rev.)

3. Evaluation of protein quality and energy value. Studies were conducted to estimate the protein quality and energy content of indigenous feedstuffs at Punjab University, Ludhiana, India. The protein quality index (PQI) was determined on cow peas, mustard oil meal, two varieties



of guar meal, lentil, ground nut meal, jowar, gram, red gram, black gram, kabli gram, metha, and deoiled rice polish. The values of PQI ranged from 29.4 for the deoiled rice polish to 86.2 for guar meal. The gross energy values of the plant materials determined by calorimeter, ranged from 406 to 457 Kcal. per 100 grams of dried material. Most of the leguminous seeds showed variable amounts of antitryptic activity (10 to 80% inhibition). However, lentil, guar meal and gram churi, which are obtained from legumes, were devoid of antitryptic activity. The available lysine content of some of the samples was estimated. (A7-AH-21)

## PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

### Nutritive Requirements

Robel, E. J. 1966. Ion exchange chromatography for the determination of tryptophan. (Abs.) Federation Proc. 25:541. (AH e2-16)

Lillie, R. J. and Denton, C. A. 1966. Effect of nutrient restriction on White Leghorns in the grower and subsequent layer periods. Poultry Sci. 44:810-818. (AH e2-16)

### Digestion and Metabolism

Menge, H., Calvert, C. C. and Denton, C. A. 1965. Influence of dietary oils on reproduction in the hen. J. Nutrition 87:365-370. (AH e2-20)

Hurwitz, S. and Barr, A. 1965. Absorption of calcium and phosphorus along the gastrointestinal tract of the laying fowl as influenced by dietary calcium and eggshell formation. J. Nutrition 86:433-438. (A10-AH-20)

Hurwitz, S. and Barr, A. 1966. Calcium depletion and repletion in laying hens. 1. Effect of calcium in various bone segments, in eggshell and in blood plasma, and on calcium balance. Poultry Sci. 45:345-352. (A10-AH-20)

Hurwitz, S. and Barr, A. 1966. Calcium depletion and repletion in laying hens. 2. The effect of radiocalcium and radiostrontium retention in bone and deposition in the eggshell. Poultry Sci. 45:352-358. (A10-AH-20)

Ascarelli, I., Budowski, P., Nir, I. and Bondi, A. 1964. The influence of thyroid status on the utilization of vitamin A and carotene by chickens. Poultry Sci. 43:370-377 (A10-AH-7)

Nutritive Value of Feeds

- Heywang, B. W. 1965. Effect of some antibiotics and furazolidone on performance of laying chickens during hot weather. Poultry Sci. 44: 1523-1527. (AH e2-15 Rev.)
- Heywang, B. W. 1965. Comparison of performance of layers fed soybean, glandless or glanded cottonseed meals. Poultry Sci. 44:1240-1244. (AH e2-15 Rev.)
- Kemmerer, A. R., Heywang, B. W., Vavich, M. G., and Sheehan, E. T. 1965. Effect of cottonseed oil on egg hatchability. Poultry Sci. 44:1315-1317. (AH e2-17 Rev.)
- Heywang, B. W. 1965. The effect of the tranquilizer reserpedine on caged White Leghorn layers during hot weather in a semiarid, semitropical climate. Poultry Sci. 44:1270-1273. (AH e2-15 Rev.)
- Budowski, P., Ascarelli, I., Gross, Jena, Nir, I. and Bondi, A. 1964. Vitamin A activity of acidulated soybean soapstocks in chicks. J. Am. Oil Chem. Soc. 41:441-445. (A10-AH-7)



Related Publications of State Experiment Stations

Nutrition

Anderson, J. O., 1965, Cottonseed meal as a protein source for poultry, Animal Nutrition and Health 20(4) pp. 11-14 Utah

Anderson, J. O. and Warnick, R. E., 1965, Amino acid deficiencies in peanut meal and in corn and peanut meal rations, Poultry Science 44(4) pp. 1066-1072 Utah

Attia, F. and Creek, R. D., 1965, Studies on raw and heated wheat germ for young chicks, Cereal Chem. 42 pp. 494-497 Md.

Arscott, G. H., 1965, Addition of dimethyl sulfoxide to chick rations, Poultry Science 44(5), pp. 1341-1342 Ore.

Arscott, G. H., Parker, J. E. and Dickenson, E. M., 1965, Effect of dietary linoleic acid, vitamin E and ethoxyquin on fertility of male chickens, Journal Nutrition 87(1) pp. 63-68 Ore.

Arscott, G. H., Hutto, D. C. and Rachapaetayakom, P., 1965, Use of barley in high-efficiency broiler rations, Poultry Science 44(2) pp. 432-434 Ore.

Askelson, C. E. and Balloun, S. L., 1965, Influence of dietary protein level and amino acid composition on chick performance, Poultry Science 44(1) pp. 193-197 Iowa

Bare, L. N., Wiseman, R. F. and Abbott, O. J., 1965, Levels of antibiotics in the intestinal tract of chicks fed bacitracin and penicillin, Poultry Science 44(2) pp. 489-491 Ky.

Beane, W. L., Siegel, P. B. and Siegel, H. S., 1965, Piperazine compounds and yolk discoloration, Poultry Science 44(3), pp. 666-668 Va.

- Biglund, C. H., Bennett, E., and Abbott, U. K., 1965, The effect of pyrrole-2-aldehyde chalcone derivatives on the incidence of blood spots in chicken eggs, Poultry Science 44(1) pp. 140-144  
Calif.
- Bird, H. R., Sullivan, T. W., Karrick, N. L. and Grau, C. R., 1965, Two methods of evaluating fish meal proteins by chick growth, Poultry Science 44(3) pp. 865-868  
Wisc.
- Brambila, S., and Hill, F. W., 1965, Paralysis induced by feeding synthetic glycerides to chicks, Proc. Soc. Expt. Biol. and Med. 118(3) pp. 845-847  
Calif.
- Bray, D. J., 1965, The methionine requirement of young laying pullets, Poultry Science 44(5) pp. 1173-1180  
Ill.
- Chou, Shih-Toon and Ross, E., 1965, Comparative vitamin K activity of dehydrated alfalfa and leucaena leucocephala meal, Poultry Science 44(4) pp. 972-974  
Hawaii
- Damron, B. L., Waldroup, P. W. and Harms, R. H., 1965, Evaluation of dried bakery products for use in broiler diets, Poultry Science 44(4) pp. 1122-1126  
Fla.
- Dean, W. F. and Scott, H. M., 1965, The development of an amino acid reference diet for the early growth of chicks, Poultry Science 44(3) pp. 803-808  
Ill.
- Deaton, J. W. and Quisenberry, J. H., 1965, Effects of dietary protein level on performance of four commercial egg production stocks, Poultry Science 44(4) pp. 936-942  
Tex.
- Deaton, J. W. and Quisenberry, J. H., 1965, Effects of Amino Acid supplementation of low protein corn and grain sorghum diets on the performance of egg production stocks, Poultry Science 44(4) pp. 943-947  
Tex.
- Dilworth, B. C. and Day, E. J., 1965, Effect of varying dietary calcium: Phosphorus Ratios on Tibia and Femur Composition of the Chick, Poultry Science 44(6) pp. 1474-1479  
Miss.
- Doberenz, A. R., Kurnick, A. A., Hulett, B. J., and Reid, B. L., 1965, Bromide and fluoride toxicities in the chick, Poultry Science 44(6) pp. 1500-1504  
Ariz.
- Donaldson, W. E., 1965, Alterations of lipogenesis in the intact chick by dietary malonic acid, Proc. Soc. Expt. Biol. and Med. 118(2) pp. 450-453  
N. C.



- Donovan, G. A., 1965, Vitamin A requirement of growing birds, Poultry Science 44(5) pp. 1292-1298 Vt.
- Edwards, H. M., Jr., and May, K. N., 1965, Studies with menhaden oil in practical-type broiler rations, Poultry Science 44(3), pp. 685-689 Ga.
- Enos, H. L. and Moreng, R. E., 1965, Evidence of genetic variability for lysine utilization, Poultry Science 44(4) pp. 964-971 Colo.
- Evans, R. J., Bandemer, S. L. and Davidson, J. A., 1965, Failure of epoxy and hydroxy fatty acids to cause egg discoloration when fed to laying hens, Poultry Science 44(4) pp. 1097-1099 Mich.
- Fisher, H., 1965, Unrecognized amino acid deficiencies of cottonseed protein for the chick, Journal Nutrition 87(1) pp. 9-12 N. J.
- Fisher, H., Siller, W. G. and Griminger, P., 1965, Restricted protein intake and avian atherosclerosis, Nature 207 pp. 329- N. J.
- Fisher, H., 1965, Further studies on the limiting amino acids in differently processed groundnut meals, Journal Science Food and Agriculture 16(7) pp. 390-393 N. J.
- Garlich, J. D. and Nesheim, M. C., 1965, Effect of sodium taurocholate on fat malabsorption induced by feeding unheated soybean proteins, Proc. Soc. Expt. Biol. and Med. 118(4) pp. 1022-1025 N. Y.
- Gehle, M. H. and Balloun, S. L., 1965, Selected hemocytological effects of vitamin B<sub>6</sub> deficiency in chicks, Journal Nutrition 87(2) pp. 197-201 Iowa
- Grimes, G. R. and Moreng, R. E., 1965, The effect of hygromycin B on the reproductive performance of two breeds of laying hens, Poultry Science 44(3) pp. 748-753 Colo.
- Griminger, P., 1965, Relative vitamin K potency of two water-soluble menadione analogues, Poultry Science 44(1) pp. 210-213 N. J.
- Hill, C. H., and Starcher, B., 1965, Effect of reducing agents on copper deficiency in the chick, Journal Nutrition 85(3) pp. 271-274 N. C.

Jensen, L., 1965, Poultry Nutrition in 1964, World's Poultry Science Journal 21(4) pp. 329-344 Wash.

Jensen, L. S., Ranit, G. O., Wagstaff, R. K. and McGinnis, J., 1965, Protein and lysine requirements of developing turkeys as influenced by pelleting, Poultry Science 44(6) 1435-1441 Wash.

Johnston, C. and Watts, A. B., 1965, The characterization of a growth inhibitor of glandless cottonseed, Poultry Science 44(3) pp. 652-658 La.

Johnston, C., Gray, J. C., 1965, Livability and growth of chicks from the first through the eleventh day of age when force fed a chemically synthetic, water soluble diet, Poultry Science 44(3) pp. 839-843 La.

Jones, J. E., Wilson, H. R., Waldroup, P. W. and Harms, R. H., 1965, Effects of dosage level and length of feeding dienestrol diacetate on potentiation of oxytetracycline, Poultry Science 44(2) pp. 486-488 Fla.

Jones, J. E., Wilson, H. R., Waldroup, P. W. and Harms, R. H., 1965, Effect of estradiol upon oxytetracycline utilization as related to blood calcium, Proc. Soc. Expt. Biol. and Med. 118(1) pp. 133-135 Fla.

Jones, V. K., Reid, B. L. and Deutschman, A. J., Jr., 1965, A positive halphen test with a non-cyclopropenoid compound, Poultry Science 44(6) pp. 1592-1593 Ariz.

Kienholz, E. W., Sunde, M. L. and Hoekstra, W. G., 1965, Effect of dietary zinc on metabolism of zinc-65 in hens, American Journal Physiol. 208(2) pp. 347-352 Wisc.

Krista, L. M., Waibel, P. E. and Burger, R. E., 1965, The influence of dietary alterations, hormones, and blood pressure on the incidence of dissecting aneurysms in the turkey, Poultry Science 44(1) pp. 15-22 Minn.

Llorico, B. F. and Quisenberry, J. H., 1965, Effects of hygromycin B on the growing and laying performance of chickens, Poultry Science 44(6) pp. 1565-1571 Tex.

Martin, G. A., 1965, Feeding requirements for growing layer-type pullets as related to body weight, Poultry Science 44(1) pp. 169-176 W. Va.



- Marrett, L. E. and Sunde, M. L., 1965, The effect of other D amino acids on the utilization of the isomers of methionine and its hydroxy analogue, Poultry Science 44(4) pp. 957-964  
Wisc.
- Moran, E. T., Jr. and McGinnis, J., 1965, The effect of cereal grain and energy level of the diet on the response of turkey poults to enzyme and antibiotic supplements, Poultry Science 44(5) pp. 1253-1261  
Wash.
- Mraz, F. R., 1965, Radioisotope and poultry, World's Poultry Science Journal 21(3) pp. 238-261  
Tenn.
- Naber, E. C. and Ware, G. W., 1965, Effect of kepone and mirex on reproductive performance in the laying hen, Poultry Science 44(3) pp. 875-880  
Ohio
- Naber, E. C., Scott, K. and Johnson, R. M., 1965, Effect of beta-aminopropionitrile on calcium metabolism in the developing chick embryo, Poultry Science 44(5) pp. 1318-1323  
Ohio
- O'Dell, B. L., Amos, W. H. and Savage, J. E., 1965, Relation of chick kidney arginase to growth rate and dietary arginine, Proc. Soc. Expt. Biol. and Med. 118(1) pp. 102-105  
Mo.
- Patrick, H., Voitle, R. A., Hyre, H. M. and Martin, W. G., 1965, Incorporation of phosphorus and selenium in cock sperm, Poultry Science 44(2) pp. 587-591  
West. Va.
- Petersen, C. F., 1965, Factors influencing egg shell quality -- A review World's Poultry Science Journal 21(2) pp. 110-138  
Iowa
- Potter, L. M., Stutz, M. W. and Matterson, L. D., 1965, Metabolizable energy and digestibility coefficients of barley for chicks as influenced by water treatment or by presence of fungal enzyme, Poultry Science 44(2) pp. 565-573  
Va.
- Reid, B. L., Heywang, B. W., Kurnick, A. A., Vavich, M. G. and Hulett, B. J., 1965, Effect of vitamin A and ambient temperature on reproductive performance of white leghorn pullets, Poultry Science 44(2) pp. 446-452  
Ariz.
- Reid, B. L., Kurnick, A. A. and Hulett, B., J., 1965, Relationship of protein level, age and ambient temperature to laying hen performance, Poultry Science 44(4) pp. 1113-1122  
Ariz.
- Ringrose, R. C., Manoukas, A. G., Hinkson, R. and Teeri, A. E., 1965, The Niacin requirement of the hen, Poultry Science 44(4) pp. 1053-1065  
N. H.

- Sauter, E. A., Petersen, C. F., Lampman, C. E. and Wiese, A. C., 1965, A study of the influence of dehydrated alfalfa meal on the production of blood spots in eggs, Poultry Science 44(1) pp. 52-62 Iowa
- Shapiro, R. and Fisher, H., 1965, The amino acid requirement of laying hens, 6. The absolute daily protein requirement for peak production, Poultry Science 44(1) pp. 198-205 N. J.
- Silvestrini, D. A., Dawson, L. E., Evans, R. J., and Davidson, J. A., 1965, Effects of nicarbazin in diet on mottled yolks  
1. Incidence and degree of mottling, and certain yolk proteins, Poultry Science 44(2) pp. 467-473 Mich.
- Singsen, E. P., Nagel, J., Patrick, S. G. and Matterson, L. D., 1965, The effect of a lysine deficiency on growth characteristics, age at sexual maturity, and reproductive performance of meat-type pullets, Poultry Science 44(6) pp. 1467-1473 Conn.
- Smith, R. E. and Scott, H. M., 1965, Use of Free amino acid concentrations in blood plasma in evaluating the amino acid adequacy of intact proteins for chick growth, 1. Free amino acid patterns of blood plasma of chicks fed unheated and heated fishmeal proteins, Journal Nutrition 86(1), pp. 37-44 Ill.
- Smith, R. E. and Scott, H. M., 1965, Use of free amino acid concentrations in blood plasma in evaluating the amino acid adequacy of intact proteins for chick growth,  
II. Free amino acid patterns of blood plasma of chicks fed sesame and raw, heated and overheated soybean meals, Journal Nutrition 86(1) pp. 45-50 Ill.
- Smith, R. E. and Scott, H. M., 1965, Biological evaluation of fish meal proteins as sources of amino acids for growing chicks, Poultry Science 44(2) 394-400 Ill.
- Smith, R. E. and Scott, H. M., 1965, Measurement of the amino acid content of fishmeal proteins by chick growth assay  
1. Estimation of amino acid availability in fish meal proteins before and after heat treatment, Poultry Science 44(2) pp. 401-408 Ill.
- Sullivan, T. W., 1965, Hemoglobin, White Cell count, packed cell volume and weight gain in turkeys fed certain antibiotics, Proc. Soc. Expt. Biol. and Med. 119(3) pp. 731-733 Nebr.
- Tarpey, R. W., Gleaves, E. W., Tonkinson, L. V. and Thayer, R. H., 1965, Evaluating dietary volume measurements, Poultry Science 44(2) pp. 495-501 Okla.



- Thayer, R. H., Tonkinson, L. V., Gleaves, E. W. and Henley, M. H., 1965, Relationship of nutrient density to nutrient intake in growing turkeys, Poultry Science 44(3) pp. 689-697  
Okla.
- Tipton, H. C., Dilworth, B. C. and Day, E. J., 1965, The relative biological value of DL-methionine and methionine hydroxy analogue in chick diets, Poultry Science 44(4) pp. 987-992  
Miss.
- Tonkinson, L. V., Gleaves, E. W., Dunkelgod, K. E., Thayer, R. H., Sirny, R. J. and Morrison, R. D., 1965, Fatty acid digestibility in laying hens fed yeast culture, Poultry Science 44(1) pp. 159-164  
Okla.
- Turk, D. E., 1965, Effects of diet on the tissue zinc distribution and reproduction in the fowl, Poultry Science 44(1) pp. 122-126  
S. C.
- Valadez, S., Featherston, W. R. and Pickett, R. A., 1965, Utilization of safflower meal by the chick and its effect upon plasma lysine and methionine concentrations, Poultry Science 44(4) pp. 909-915  
Ind.
- Vohra, P. and Kratzer, F. H., 1965, Improvement of guar meal by enzymes, Poultry Science 44(5) pp. 1201-1205  
Calif.
- Waldroup, P. W., Harms, R. H. and Fried, M., 1965, Alterations in the serum protein components of laying hens on low protein diets, Poultry Science 44(1) pp. 213-215  
Fla.
- Waldroup, P. W., Stearns, J. E., Ammerman, C. B. and Harms, R. H., 1965, Studies on the vitamin D<sub>3</sub> requirement of the broiler chick, Poultry Science 44(2) pp. 543-548  
Fla.
- Waldroup, P. W., Ammerman, C. B. and Harms, R. H., 1965, The availability of phytic acid phosphorus for chicks, 4. The availability of natural plant phosphorus, Poultry Science 44(3) pp. 880-886  
Fla.
- Waldroup, P. W., Van Walleggem, P., Fry, L., Chicco, C. and Harms, R. H., 1965, Fish meal studies, 1. Effect of levels and sources on broiler growth rate and feed efficiency, Poultry Science 44(4) pp. 1012-1016  
Fla.
- Waldroup, P. W., Ammerman, C. B. and Harms, R. H., 1965, Studies on the acidulation of soft phosphate, Poultry Science 44(6) pp. 1519-1523  
Fla.

Waldroup, P. W., Ammerman, C. B. and Harms, R. H., 1965, The utilization of phosphorus from animal protein sources for chicks, Poultry Science, 44(5) pp. 1302-1306 Fla.

Waldroup, P. W., Ammerman, C. B. and Harms, R. H., 1965, A comparison of phosphorus assay techniques with chicks, Poultry Science 44(4) pp. 1086-1089 Fla.

Wessels, J. P. H. and Fisher, H., 1965, The nutritional requirements of the protein-depleted chicken. Amino acid requirements for repletion of adult cocks depleted by starvation, Brit. J. Nutrition 19(1) pp. 71-78 N. J.

Wilson, H. R., Waldroup, P. W., Jones, J. E., Duerre, D. J., and Harms, R. H., 1965, Protein levels in growing diets and reproductive performance of cockerels, J. Nutrition 85(1) pp. 29-37 Fla.

Zimmerman, R. A. and Scott, H. M., 1965, Interrelationship of plasma amino acid levels and weight gain in the chick as influenced by suboptimal and superoptimal dietary concentrations of single amino acids, J. Nutrition 87(1) pp. 13-18 Ill.

### Management

Al-Timimi, Ali A., Owings, W. J. and Adams, J. L., 1965, The effect of volume and surfact area on the rate of accumulation of solids in indoor manure digestion tanks, Poultry Science 44(1) pp. 112-115 Nebr.

Beane, W. L., Siegel, P. B. and Siegel, H. S., 1965, Light environment as a factor in growth and feed efficiency of meat-type chickens, Poultry Science 44(4) pp. 1009-1012 Va.

Clark, C. E. and Amin, M., 1965, The adaptability of chickens to various temperatures, Poultry Science 44(4) pp. 1003-1008 Utah

Hargreaves, R. C. and Champion, L. R., 1965, Debeaking of caged layers, Poultry Science 44(5) pp. 1223-1227 Mich.

Harper, J. A. and Parker, J. E., 1965, Effect of light and drugs in controlling egg production of turkeys, Poultry Science 44(3) pp. 778-784 Ore.



Kellerup, S. U., Parker, J. E. and Arscott, G. H., 1965, Effect of restricted water consumption on broiler chickens, Poultry Science 44(1) pp. 78-83 Ore.

Longhouse, A. D., Heishman, J. O. & Cunningham, J. C., 1965, West Virginia's new housing and management system for raising broilers, Bulletin 508, June 1965 W. Va.

Parker, J. E. and McCluskey, W. H., 1965, The effect of length of daily light periods on sexual development and subsequent fertilizing capacity of male chickens, Poultry Science 44(1) pp. 23-27 Ore.

Wilson, W. O., Mather, B. F. and Tanaka, K., 1965, Maintenance of egg production in cotournix following reduction in photoperiod, Poultry Science 44(5) pp. 1299-1302 Calif.

Wisman, E. L. and Beane, W. L., 1965, Effect of some management factors on the incidence of breast blisters in heavy broilers, Poultry Science 44(3) pp. 737-741 Va.

## AREA NO. 12: POULTRY - IMPROVEMENT OF VIABILITY

Problem. Leukosis continues to head the list of diseases that cause a high mortality among chickens. It is prevalent in both young and mature stocks, and on most, if not all farms where chickens are reared. It is also responsible for high rates of condemnation at processing plants and poor performance with respect to growth and egg production.

The yearly financial losses to the poultry industry of the United States from leukosis alone are estimated to be in excess of \$160 million. At this time when the margin between the cost of production and the price received for poultry products has been reduced to a very low figure, it is more urgent than heretofore that additional emphasis be placed on research directed toward the development of effective control measures for the leukosis complex. Also, such studies with chickens continue to be invaluable models for research on leukemia in other animals and man.

### USDA AND COOPERATIVE PROGRAM

This is a continuing program in virology, pathology, immunology, epizootiology and genetics on basic and applied studies of the neoplasms of the avian leukosis complex. Most of the studies are conducted at the Regional Poultry Research Laboratory, East Lansing, Michigan. Work is also done in cooperation with more than a dozen other Federal, State or commercial agencies located in several sections of the United States.

The primary objective of these studies is to develop a practical program for the prevention of losses due to the diseases of the avian leukosis complex. Most of the effort has been and currently is directed toward two approaches. The first is to develop a program to increase resistance of the chicken to avian leukosis. It has been found that the level of viral stimulated antibodies and certain yet undefined physiologic mechanisms are genetically controlled and have very important influences on resistance. For significant progress in this approach it has become evident that basic studies must continue to be conducted on (1) mode of inheritance, (2) mechanism of gene expression, (3) interrelationships of resistance to different tumor viruses, avenues of exposure, and other genetically controlled traits, (4) dynamic interrelationship between infection, antibody, and neoplasms, (5) ultra-structure, biochemistry and the molecular biology of the causative virus and infected cells, and (6) the mechanism of influence of the bursa of Fabricius on neoplasia.

The second approach is directed toward the prevention of infection and/or elimination of the disease. Avian leukosis is a contagious disease. The infectious virus is transmitted not only by direct contact with infected chickens, with infected environment, and with insect vectors, but also via the infected embryonating egg. The most important prerequisite for progress



in the development of eradication measures is a simple but adequate method of detecting current or past infection. Only recently has notable progress been made on this aspect, and further simplification of procedures can be expected. Such fundamental epizootiological information as the extent and prevalence of infection, the modes of spread of infection, the importance of various vectors and reservoirs, the importance of various environmental factors and other concomitant diseases, and the influence of passive as well as active immunity must be obtained before a rational program of eradication can be developed.

Recent developments have demonstrated that there are at least two different families of viruses -- not one as formerly thought -- that cause similar types of leukosis. This emphasizes the magnitude of the problem that still faces us, but at the same time clarifies the problem so that studies can be planned with a much greater expectancy of significant results than heretofore.

Research contracts are in effect with Cornell University, the University of Connecticut, University of Georgia, University of California, University of Arkansas, and University of Massachusetts. In addition, cooperative agreements with at least seven universities or commercial concerns were in effect during the reporting period. Also cooperating in this area of research are the National Institutes of Health, the American Cancer Society, and the Animal Health Division and the Animal Disease and Parasite Research Division of the Agricultural Research Service. A Public Law 480 Project has been initiated with the Institute for Biological Research, Ness-Ziona, Israel, (four years, 1966-1970). The project is concerned with obtaining estimates of the incidence of avian lymphomatosis in Israel, the epizootiology of causative viruses, and development of a rapid method of diagnosing the disease.

The Federal scientific effort devoted to the research in these areas during the past year totaled 9.5 scientific man-years. Of this number, 2.5 were devoted to etiology and pathology, 2.5 to immunology and serology, 2.0 (3.3) to epizootiology, 2.0 to genetics, and 0.5 to biophysics and biochemistry. (The figures in parentheses include 1.3 professional man-years from the Animal Health Division).

#### PROGRAM OF STATE EXPERIMENT STATIONS

The total research effort on improvement of viability in poultry by State agricultural experiment stations is 1.0 scientific man-years.

#### PROGRESS -- USDA AND COOPERATIVE PROGRAMS

##### A. Etiology and Pathology

The JM strain of Marek's disease has been passaged as a cellular suspension 25 times without observable change in its potency or pathologic



manifestations. However, potency of twice-centrifuged JM plasma, as estimated from single dose inoculation responses, has varied widely. The agent has been isolated routinely from washings obtained from the oral cavity, cloacal swabs, and litter from infected birds. The infectivity in litter or droppings persisted throughout a 16-week holding period at room temperature. The mechanism for this prolonged survival of JM in litter is currently being investigated. These observations may be of significance in understanding the transmission of Marek's disease under natural conditions.

The GA strain of Marek's disease was obtained from Dr. S. C. Schmittle, University of Georgia, and has been passaged in chickens 6 times at this Laboratory. The potency and pathologic manifestations of this strain have varied considerably with passage. The incidence of visceral tumors in affected birds is much greater than in birds exposed to JM. Most GA-inoculated birds have nerve lesions although in many cases these are seen only on microscopic examination.

Attempts were made to propagate the JM and GA strains in various tissue culture systems. Marek's disease was induced in chicks inoculated with (1) normal embryo cells inoculated with JM blood, (2) cultures prepared from embryos previously inoculated with JM or GA blood, and (3) bone marrow and gonadal cultures from JM-inoculated 10-week-old birds. Spleen and bone marrow cultures gave stronger responses than fibroblasts or gonadal cells. Cultures inoculated with GA blood or cultures from embryos inoculated with cell-free preparations of JM were negative. These results show that Marek's infected cells can be cultivated in vitro and that normal cultures can be infected with cellular inocula containing the Marek's agent. This constitutes an important first step in the development of a cell culture assay system for the etiological agents of Marek's disease. (AH e6-30)

Research done under USDA contract by the University of Georgia has established the relative susceptibility of certain lines and crosses of chickens to the GA strain. Line 7 was most susceptible, line 6 was most resistant, and line 15I and various commercial lines had intermediate susceptibility. These susceptibility rankings to GA were virtually identical to rankings for JM exposure obtained in trials conducted at East Lansing. In other studies, passage of GA with plasma inocula has been routinely successful. Attempts to demonstrate an effect of coccidiosis on Marek's disease, either through induction of Marek's disease by contaminated oocysts or through enhancement of Marek's disease by subsequent coccidial infection, have failed. (AH e6-30)

Studies conducted by the University of Connecticut under USDA contract have elucidated some biocharacteristics of the CONN-A strain of Marek's disease. Preliminary results indicate that this agent can be propagated in fibroblast and bone marrow cultures. Infected cultures often show a mild degenerative change in later passages. Fluorescent antibody and agar gel precipitin technics have successfully been applied to the detection of Marek's antigens in infected birds or cell cultures. Attempts to adapt these technics to the in vitro assay of Marek's disease agents are in progress. (AH e6-30)



Previous studies have shown that normal bursa of Fabricius is necessary for the development of lymphoid leukosis. Surgical removal prevents the neoplasm. Dipping fertile eggs in a solution of testosterone propionate causes a marked reduction in the lymphoid tissue of the bursa, but it has an adverse effect on hatchability. Recent experiments on the injection of day-old chicks with testosterone suggest that this may be a more practical procedure for the prevention of lymphoid leukosis. No leukosis has developed in chickens that had been given a series of 4 injections, whereas no treated controls developed a high incidence. Preliminary experiments suggest that the number of injections may be reduced to one and still obtain the desired effect. (AH e6-33)

One-day-old line 15I chicks inoculated with RPL12 virus, and controls were examined at monthly intervals. Tissues were collected for histological, ultramicroscopic, virological and serological examinations. Results indicate that lymphoid leukosis commences as a malignant transformation of lymphoid cells in lymphoid follicles of the bursa of Fabricius. This transformation was seen as early as 2 months after infection, and the malignant cells later metastasized to other organs, notably the liver and spleen. The first death from lymphoid leukosis occurred at 5 months. (AH e6-33)

#### B. Immunology and Serology

Based on differences in host range and interference of virus growth in tissue culture, the viruses of the leukosis/sarcoma group have been divided into subgroups A, B, and C. To determine the serologic variation between virus strains or isolates of these subgroups, 11 different virus strains or pseudotypes have been propagated, homologous antiserums prepared, and serologic interrelations studied by using the neutralization test. There has been found essentially no cross neutralization between the reagents of different subgroups.

In general, sera that are active against one subgroup A virus are reactive with other strains of the subgroup A, although there are important quantitative differences. However, there appears to be considerable heterogeneity between members of the subgroup B. Thus, antisera highly active against one subgroup B strain may have little or no activity against another strain of this subgroup.

Limited neutralization tests of serum from commercial flocks indicate that BS-RSV is the most sensitive for detecting the subgroup A antibodies. For the detection of the subgroup B antibodies more than one virus strain will have to be employed. The most sensitive strain still needs to be determined. The prevalence of subgroup B antibodies in natural infection appears to be much less than subgroup A, and those of subgroup C have as yet not been detected. (AH e6-32)

Four field strains of lymphoid leukosis -- RPL25 (Bower), RPL28 (Strickland), RPL29 (Petoskey) and RPL30 (Pierceton) -- were examined to determine the



subgrouping. The criteria used were in vitro susceptibility of specific cell types, interference of virus growth by specific prototype viruses, and responses of chicks of specific susceptibilities to inoculation with the test strains. The in vivo and in vitro data are confirmatory and indicate that RPL25 is primarily, if not entirely, of subgroup B virus, and the remaining three strains are primarily of subgroup A virus. This again indicates that subgroup A virus infections are much more prevalent than subgroup B virus. (AH e6-32).

### C. Epizootiology

The highly inbred line 15I has been maintained in isolation for over 20 years. A low level of lymphoid leukosis and Marek's disease has been experienced even though extensive testing of serums has not revealed any antibody positive chickens. More recently a transmissible agent has been isolated from chick embryo fibroblast cultures which has many characteristics of a lymphoid leukosis virus; however, initial tests have not shown it to be pathogenic. (AH e6-3)

Epizootiologic studies supported in part by funds of the National Cancer Institute have been completed. These concerned the occurrence of leukosis virus and antibody, and the mortality among chickens on two large commercial farms. The two farms had a marked difference in leukosis mortality. On both farms the percent of plasmas tested that had antibodies to subgroup A or subgroup B leukosis/sarcoma viruses increased with age of the chicken, and at sexual maturity was at a high level. However, there was no difference between the farms studied in the occurrence of antibody or of viremic chickens which might have been related to the marked difference in mortality. Pathological studies revealed that most of the leukosis mortality was due to Marek's disease which is etiologically and serologically unrelated to the leukosis/sarcoma (lymphoid leukosis) group of neoplasms. It is apparent that further field studies must await the development of laboratory methods for the detection of the infectious agent or antibody of Marek's disease. (AH e6-27)

The laboratory has completed an extensive search for evidence of infection in humans with viruses of the avian leukosis/sarcoma RIF positive group. Over 350 serums or plasma were examined for virus or antibody. These samples were drawn from various groups, including (a) persons of different ages with various types of leukemia, (b) others having direct contact with poultry over long periods, (c) individuals having direct contact with various types of avian neoplasms, and (d) others having had no or little contact with chickens. Many plasmas or serums gave an inhibitory effect in a tissue culture antibody test; however, all such samples that were rechecked in an embryo test were negative. It was found that all such false positives were due to methods of collecting the plasma or serum samples. Thus, it was found that certain vacutainers used in collecting samples, and heparin and citrate when used as anticoagulant, may result in false positives in the tissue culture test, yet negative in the embryo test.



It can be said without doubt that no evidence for antibody to the viruses of the avian leukosis/sarcoma, RIF positive group was found.

Some of the samples were also examined for viral antigen by the COFAL test, and all were negative. This reinforces the proposition that humans are not susceptible to infection with the avian tumor viruses. (AH e6-27)

#### D. Genetics

Four of the lines established in 1939 and maintained under moderate inbreeding have now been reproduced by full brother-sister matings for five generations. It appears that sublines of each line will withstand this mating system and retain reasonable reproductive ability. Exchanges of skin grafts among birds within sublines indicated that it may be possible to obtain isohistogenic sublines in two or three of these lines. The availability of such lines will be invaluable in the study of the physiologic mechanism of genetic resistance and for studies of the role of the immune system of the chicken in the avian leukosis complex. (AH e6-2, 28)

Continuing studies on the single gene systems involved in cellular resistance to the leukosis-sarcoma viruses have definitely established the existence of two independent genetic loci controlling resistance to different subgroups of these viruses. Preliminary evidence suggests that both these loci may influence resistance to virus strains thought to belong to a third subgroup of leukosis viruses. However, neither appears to have any influence on susceptibility to Marek's disease which is now thought to be induced by an agent belonging to a separate etiologic group, but still belonging to the avian leukosis complex. (AH e6-29)

One generation of selection of a random bred stock toward resistance and toward susceptibility to Marek's disease, induced by the injection of cell suspensions of JM tumors has been completed under research contracted to Cornell University. A progeny test of the first selected generation revealed a difference of more than 40% between the resistant and susceptible lines. This indicates that differences in susceptibility to JM induced Marek's disease are highly heritable. This project will be continued for at least three generations of selection, at which time exposure to the avian leukosis complex under field conditions is contemplated. These and other results indicate that genetic differences in susceptibility to Marek's disease should be recognized and investigated for use by commercial breeders. (AH e6-29)

Histochemical staining and quantitative methods were used to study the oxidative enzymes of the thymus, bursa of Fabricius and the spleen of 20-day embryos of inbred lines 6, 7 and 15I. Results indicate that enzymatic activity is more intense in the bursa of chickens of the susceptible line than in bursa of resistant lines. Studies are being continued to determine the significance of these differences. This research was conducted under a cooperative agreement with Michigan State University. (AH e6-29)

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

- Biggs, P. M., Purchase, H. G., Bee, B. R. and Dalton, P. M. 1965. Preliminary report on acute Marek's disease (fowl paralysis) in Great Britain. Vet. Record 77: 1339-1340. (AH e6-10)
- Burmester, B. R. 1965. The avian leukosis complex in the United States. Memoria II Symposium de Patologia Aviar (Terragona, Spain), pp. 113-143. (AH e6-10)
- Crittenden, L. B. 1965. Maintenance of single-gene segregation controlling susceptibility to Rous sarcoma virus in poultry flocks. Genetics 52: 438. (AH e6-29)
- Crittenden, L. B. and Okazaki, W. 1965. The genetic influence of the Rs locus on susceptibility to avian tumor viruses. I. Neoplasms induced by RPL12 and three strains of Rous sarcoma virus. J. Nat. Cancer Inst. 35: 857-863. (AH e6-29)
- Crittenden, L. B. and Okazaki, W. 1966. The genetic influence of the Rs locus on susceptibility to avian tumor viruses. II. Rous sarcoma virus antibody production after strain RPL12 virus inoculation. J. Nat. Cancer Inst. 36: 299-303. (AH e6-29)
- Payne, F. E., Solomon, J. J. and Purchase, H. G. 1966. Immunofluorescent studies of group-specific antigen of the avian sarcoma-leukosis viruses. Proc. Soc. Acad. Sci. 55: 341-349. (AH e6-17)
- Peterson, R. D. A., Purchase, H. G., Burmester, B. R., Cooper, M. D. and Good, R. A. 1966. The relationships among visceral lymphomatosis, the bursa of Fabricius and the bursa-dependent lymphoid tissue of the chicken. J. Nat. Cancer Inst. 36: 585-598. (AH e6-33)
- Purchase, H. G., Cunningham, C. H. and Burmester, B. R. 1966. Identification and epizootiology of infectious bronchitis in a closed flock. Avian Diseases 10: 111-121. (AH e6-27)
- Purchase, H. G., Cunningham, C. H. and Burmester, B. R. 1966. Genetic differences among chicken embryos in response to inoculation with an isolate of infectious bronchitis virus. Avian Diseases 10: 162-172. (AH e6-28)
- Solomon, J. J., Reamer, R. H. and Okazaki, W. 1966. Artifacts induced by potassium citrate in chick embryo cells resembling Rous sarcoma virus foci. Avian Diseases 10: 94-97. (AH e6-24)



Related Publications of State Experiment Stations

Poultry Improvement of Viability

Dunlop, W. R., Kottaridis, S. G., Gallagher, J. R., Smith, S. C. and Strout, R. G. 1965. The detection of acute avian leucosis as a contagious disease. Poul. Sci. 44 (6), pp. 1537-1540.  
New Hampshire.

Grun, J. and Wogan, G. N. 1965. Studies on the passive transfer of immunity with Newcastle disease virus in relation to deutectomy. Poul. Sci. 44 (1), pp. 145-149.  
New Jersey.

Raggi, L. G. and Lee, G. G. 1965. Duration of immunity to infectious laryngotracheitis. Poul. Sci. 44 (2), pp. 509-514. Calif.

Sanger, V. L. and Holt, J. A. 1965. Experimental tetracycline labeling in avian osteopetrosis. Can. J. Comp. Med. & Vet. Sci. 29 (10), p. 245.  
Ohio.

Sanger, V. L., Holt, J. A. and Reynolds, W. A. 1965. Surface temperatures of avian osteopetrotic bones. Can. J. Comp. Med. & Vet. Sci. 29 (10), p. 259.  
Ohio.

### AREA NO. 13: POULTRY - BROILER LOSSES

Problem. It is necessary to determine the causes of the continuing losses from condemnations - a major problem of the broiler industry. The chronic respiratory disease complex, commonly referred to as CRD or air sac disease, is one of the principal causes of condemnations. The presence or absence of pathogenic strains of the pleuropneumonia-like organism, Mycoplasma gallisepticum, largely determines whether chickens will develop air sac disease in the presence of Newcastle disease, infectious bronchitis, or secondary invaders, such as E. coli. Knowledge is needed of the fundamental principles regulating the behavior of the organisms associated with the CRD complex and the host response to them. The great range in host response indicates that genetic variation, nutrition, environment, and management play a part in the severity of the response of individual flocks of chickens. Additional basic information is needed on the effect of stresses on the physiological well-being of the broiler chicken. It is of practical importance to know more of the poultry housing and management factors which adversely affect the bird.

#### USDA AND COOPERATIVE PROGRAM

A basic and applied program of research directed toward the reduction of losses from broiler condemnations is conducted jointly by specialists in agricultural engineering, animal diseases, poultry management, genetics, biochemistry, and physiology. Two locations are involved in this work, the Southeast Poultry Research Laboratory, Athens, Georgia, and the South Central Poultry Research Laboratory, State College, Mississippi. The Animal Husbandry Research Division's work at Athens emphasizes genetics and physiology in relation to the chronic respiratory disease complex and the work at State College emphasizes environment, management, physiology, and nutrition in relation to condemnation losses.

This research program is cooperative with the Animal Disease and Parasite and Agricultural Engineering Research Divisions, ARS. Local cooperation of State experiment stations and the broiler industry in the southeast and south central regions is an important part of the program, particularly with respect to field trials.

The Federal effort devoted to research in this area totals 5.0 scientific man-years. Of this number 2.0 is devoted to management practices, 1.0 to genetic control, and 2.0 to environmental physiology.

#### PROGRAM OF STATE EXPERIMENT STATIONS

The total research effort on environment as related to broiler losses by State agricultural experiment stations is 7.6 scientific man-years.



PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Genetic Control

Cooperative work was continued with ADP personnel on the titration of Newcastle Disease Vaccine (NDV) in eggs (embryo challenge) from individual Athens Rando-bred hens. One to four embryo tests were run on egg samples from 196 hens in 26 single-male matings. Although the individual titres ranged from 7.6 to 9.5, there was no consistent difference between families of daughters of F<sub>1</sub> hens selected for resistance to NDV and those selected for susceptibility. When full-sister groups were compared on the basis of embryo-test results, however, those of one hen showed sufficient consistency for resistance that three of her sons were used. Embryo tests subsequent to the introduction of these males gave a titre reduction of nearly one log for 9 of 19 hens tested, and for 3 others there was no significant change from previously resistant titres. The remaining 7 had titres which remained in the susceptible range for all tests.

Aerosol challenge of 2-week-old chicks was limited to tests on 166 surplus cockerels (not required for reproduction) from 23 dams in "resistant" matings and 133 from 24 dams in "susceptible" matings. In the resistant group 41.5% survived the L.D.50 dose, while in the susceptible group 17.3% survived. Average days to death for those which succumbed were 8.9 in each group.

For the 1966-67 tests, daughters of 33 susceptible F<sub>2</sub> dams have been placed in 15 pens and daughters of 32 "resistant" group dams in 19 pens. (AH e7-2)

B. Management Practices

The criteria used in these studies included growth, feed conversion, livability, and percent condemnation in crossbred broilers. Comparisons were continued of ambient temperatures outside gas-burning canopy brooders, and at a constant temperature between canopy hovers 74 and 99 inches in diameter. As in previous studies at 40°F, there were no marked differences in growth, feed efficiency, or condemnation rate between canopy hovers 74 inches and 99 inches in diameter when the room temperature was either 60°F or 70°F. In one study, chicks from flocks tested negative to the S-6 strain of PPLO (M. gallisepticum) were compared with chicks of which 1% were artificially infected at one day of age with M. gallisepticum. With temperatures at 60°F and 70°F and 74 inch and 99 inch canopies, the results were similar with the noninfected chicks and with those in which 1% were infected at one day of age.

Without canopies and with 3% of the chicks PPLO-infected at one day of age, various room temperatures for the first 4 weeks and constant and cyclic temperatures from the fifth to the eighth week were compared in the climatic chambers. Under the conditions of the trials, the low temperature in each comparison did not consistently affect the body weight or the condemnation

rate of the birds at market age. A better feed conversion was obtained for birds reared in the warmer temperatures.

Indications of a sex-density and a sex-temperature interaction were noted for body weight gain.

The insulation studies have been continued. From the four groups of birds grown in insulated and non-insulated pens of the four test houses, the birds from the insulated pens had a higher average body weight, better feed efficiency, lower mortality, lower brooding cost, and a higher condemnation loss than birds grown in the non-insulated pens. The non-insulated pens gave the reduced condemnation during the coldest period.

There seems to be more advantage in using a brooder, such as the "pancake" type, to provide a better temperature condition in an insulated house, than in the other types tested.

Brooding cost was reduced to approximately 50% of the regular insulated pens and 35% of the regular non-insulated pens during mid-winter periods when a portion of the broiler house was separated off for starting baby chicks. However, ventilation was more critical with this multiple-pen system.

With the temperatures encountered during the summer of 1965, the use of fans moving approximately 3cfm of air per bird and set to come on at 80°F did not show much advantage in broiler performance.

In air-flow studies, the carbon dioxide and ammonia content of the pen is reduced as the ventilation rate is increased from 0.5 to 3 cfm per bird. (AH e7-4)

### C. Environmental Physiology

Eight sire families were selected for their responses to adrenocorticotropin (ACTH) and hydrocortisone as a result of the analysis of the initial screening of 32 families of Athens Randombreds. Of these, 4 were consistently high and 4 consistently low in several response criteria. These criteria included changes in adrenal and bursa weights; adrenal cholesterol and corticosterone; and plasma glucose, cholesterol and corticosterone levels. These families are currently being tested more intensively for their blood cellular and chemical changes as a result of long-term hormonal stimulation, and of excessive heat as an environmental stressor. (AH e7-3).

Nine experiments were conducted in cooperation with AERD, which involved 72 broiler chicks. Physiological sensors to monitor respiration, heart rate, and deep body temperature were implanted and birds were subjected to high ambient temperatures with varying air velocities. Thus far, results indicate that higher air velocities may be helpful if ambient temperature does



not exceed body temperature, but may reduce the ability to withstand heat when ambient temperatures are above that of the body.

D. Effects of Fumigation

In cooperative work with ADPRD, to study the control of Salmonella in hatching eggs, a series of preincubation fumigation trials were made with White Leghorn eggs. Hatchability was compared, in each of four trials, between recommended levels (0.8g Potassium Permanganate + 1.2ml formaldehyde, ARS misc. Publ. #739) and one, two, three, four and five times this amount prior to incubation. Although hatch of fertile eggs was lower in groups fumigated with more than three times the recommended levels, the differences were not statistically significant. In subsequent tests White Leghorn and brown shelled eggs will be compared.

Determinations of formaldehyde remaining on the egg shell or in the albumin after fumigation are also being conducted. Amounts of formaldehyde remaining on the shell are rapidly reduced within one-half hour after fumigation. The concentration found in the albumin is very low.

Related Publications of State Experiment Stations

- Adler, H. E. 1965. The control of egg-transmission of M. Gallisepticum in chickens. W. Poul. Sci. J. 21 (3), pp. 262-266. California.
- Cole, John R., Jr. and Boyd, Frank M. 1965. Chemical analyses of the blood of chicks infected or endointoxicated with Escherichia coli. Poul. Sci. 44 (6), pp. 1551-1555. Georgia.
- Dixon, C. F. and Hansen, M. F. 1965. Helminths of poultry in Kansas. Poul. Sci. 44 (5), pp. 1307-1315. Kansas.
- Kemp, R. L. and Reid, W. M. 1965. Pathogenicity studies on Trichomonas gallinarum in domestic poultry. Poul. Sci. 44 (1), pp. 215-221. Georgia.
- Messersmith, Donald H. 1965. Avian infectious synovitis: A review of the literature. World's Poul. Sci. J. 21 (4), pp. 358-364. Virginia.
- Batton, W. H. 1965. Eimeria tenella: Cultivation of the asexual stages in cultured animal cells. Sci. 150 (3697), pp. 767-769. Pennsylvania.
- Stephens, J. F., Taylor, R. O. and Barnett, B. D. 1965. Coccidiosis as a stress factor in the development of air sac disease. Poul. Sci. 44 (1), pp. 165-169. S. Carolina.
- Vatne, R. D. and Hansen, M. F. 1965. Larval development of cecal worm (Heterakis gallinarum) in chickens. Poul. Sci. 44 (4), pp. 1079-1085. Kansas.
- Wisman, E. L. and Beane, W. L. 1965. Effect of some management factors on the incidence of breast blisters in heavy broilers. Poul. Sci. 44 (3), 737-741. Virginia.



#### AREA NO. 14: SHEEP AND GOATS - BREEDING

Problem. The existence of the sheep industry in this country will depend upon sheep producers being able to effectively and efficiently meet competition from other sources of meat and fiber. To meet this competition the farm sheep producer will need more efficient sheep, sheep which are capable of year-round production of more lambs and wool per ewe, often under adverse environmental conditions and with more resistance to disease and parasites. Range sheepmen need information on genetic methods of improving lamb and wool production. More effective systems of mating, breeding, and selection need to be tested. Breeding studies on reproductive efficiency, inheritance of feed efficiency, rate of gain, and carcass as well as wool quality, deserve emphasis.

#### USDA AND COOPERATIVE PROGRAM

This is a continuing program by geneticists on basic and applied studies of breeding to increase efficiency of production of high quality lamb and wool. Work in progress at Beltsville, Maryland, involves breed comparisons, studies of gains resulting from crossing of breeds, and selection for increased lamb production. At Dubois, Idaho, systems of mating are compared including development and crossing of inbred lines and selected strains. Also studies on heritability and other genetic parameters of economic traits, as well as studies on improved methods of selection are conducted. At Fort Wingate, New Mexico, and on a private ranch in Utah, selection studies are emphasized. Cooperation is maintained with 15 State experiment stations. Several of the studies contribute to the western, southern, and north central regional sheep breeding projects.

The Federal scientific effort devoted to research in this area totals 3.9 scientific man-years. Of this number 1.2 are devoted to genetics and interrelation of performance traits, and 2.7 to selection and systems of breeding.

#### PROGRAM OF STATE EXPERIMENT STATIONS

The total research effort on sheep and goat breeding by State agricultural experiment stations is 13.3 scientific man-years.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Genetics and Interrelations of Performance Traits

1. Genetic and environmental interactions. Genetic and environmental interactions were examined on 10 weanling traits of 440 crossbred lambs involving the Rambouillet, Targhee, Columbia and Suffolk breeds at Dubois, Idaho. Lambs were first observed at an average age of 83 days when a random half were weaned and put on a 37% concentrate, self-fed pellet plus native grass pasture and the remainder were left on their dams and taken to high mountain summer range. Final observations on all lambs were made at time of weaning the mountain grazed group, at an average age of 120 days.

Highly significant grazing group differences were observed for 7 of the 10 traits, and highly significant breed group differences were observed for 9 of the traits. However, the interactions between grazing groups and breed groups were barely significant for only 3 traits - body type, condition (fatness), and fleece grade on the thigh. There seems to be little evidence that different kinds of crosses among these four breeds react differently to the two different environments in weight, daily gains, face cover, neck folds, staple length, fleece grade, and uniformity of grade. (AH 1-5, 6)

2. Genetic and environmental factors affecting carcass traits of lamb. At Fort Wingate, New Mexico, carcass data were obtained on 203 ram lambs and 186 wether lambs fed rations of two energy levels and representing four lines of breeding. Lambs from the fine-wool breeding had heavier kidney knobs, more fat trim and smaller loin eye areas than lambs from 1/2 blood- and 1/4 blood-wool-type breeding. Three-year-old ewes produced lambs with better quality carcasses than older ewes. The high energy ration produced fatter carcasses than the low energy ration. Excessive subcutaneous fat was found to exert a significant negative effect on pounds of retail meat. Loin eye area showed a low relationship with measures of amount of retail meat, while measure of fat showed a high negative relationship. Ram lambs yielded more retail meat, had smaller kidney knobs, and had less excessive fat trim than wether lambs. The coarser woolled lambs, the wether lambs, and lambs from the high energy ration were the most tender. (AH 1-10,11,12)

3. Genetic and environmental factors of sheep under arid conditions. The effects of several measurable environmental factors on birth weight, weaning weights, yearling body weight, grease fleece weight, clean fleece weight, staple length, and fiber diameter, were measured at Fort Wingate, New Mexico. The heritabilities and the genetic and phenotypic correlations among these traits also were determined. The data included 3264 lambs born from 1950 through 1961. All environmental and genetic factors studied (years, breed groups, type of birth, age of dam, sex, and age of individual) had significant effects on the traits studied with the exception of age of dam on staple length and type of birth on fiber diameter. Heritabilities were computed from both paternal half-sib correlations and from regression of offspring on dam. The paternal half-sib heritability estimates ranged



from .19 for yearling body weight to .43 for yearling grease fleece weight. The regression of offspring on dam estimates ranged from .29 for weaning weight to .53 for yearling body weight. Moderate positive genetic correlations were found between body weights at different ages and between the various wool traits; except for a high positive relationship between weaning and yearling body weight, and between grease and clean fleece weight. Negative genetic correlations were found between body weight and fleece weight, staple length, and fiber diameter. (AH bl-10, 11, 12)

## B. Selection and Systems of Breeding

1. Breed comparisons and crossbreeding. Five breeds of sheep are being compared at Beltsville, Maryland, with respect to their production of wool and lamb as purebreds and their relative merit in a crossbreeding program. This comparison is based on an index that considers both pounds of lamb weaned and pounds of wool sheared. The index ranks the purebred Targhee (114.1) first, followed by Suffolk (105.5), Columbia-Southdale (87.2), Hampshire (66.1), and Dorset (42.4). All possible crosses and reciprocal crosses among the breeds were made. The Targhee X Columbia-Southdale had the highest index, with an average of the two crosses being 123.6; followed by the Hampshire X Columbia-Southdale, with an average of 115.8; the Suffolk X Targhee crosses, with 111.8; and the Suffolk X Columbia-Southdale crosses with an average of 107.3. Crosses involving Dorset rams were low because of low fertility in two of the Dorset rams. For the crossbred matings, exclusive of the crosses involving Dorset rams, the index values ranged from 123.6 to 86.6, compared to 114.1 to 66.1 for the purebred matings. (AH bl-1, 2, 3)

2. New strain of sheep for lamb and wool production. In 1961 work was started at Beltsville to develop by selection a strain of sheep capable of lambing at any time of the year and more often than once each year. At present ewes in this strain are bred to lamb three times in two years. Lambing is in September, January, and May. To date a total of 344 ewes have lambed since September 1961, producing 467 lambs of which 59 were born dead and 315 lived to weaning at about 60 days of age. The conception rate in the ewe is lowest in the spring breeding, and lamb mortality is highest in the lambs born in the fall. Selection of sires used in this strain is based on the lamb production of their mothers. Only those rams born of highly fertile and prolific ewes, capable of fall lambing, are used in breeding. The rams used in breeding were born of ewes which averaged 233% lambs weaned per ewe year and which weaned an average of 126 pounds of lamb at about 2 months of age. (AH bl-17)

3. Selection for weight and rate of gain in ewe lambs. To obtain information on the most effective period during an animal's growth in which to select for weight and rate of gain, ewe lambs were weighed at birth in April, at weaning in August, and then at monthly intervals until shearing in May. Separate determinations were made on inbred, noninbred and crossbred groups, involving Rambouillet, Targhee, and Columbia breeds.

4. Testing of inbred lines. Data at Dubois, Idaho, from 1962 through 1965 have been summarized on the performance of Rambouillet, Targhee, and Columbia inbred lines. Information is available on reproductive, weanling, and yearling performance of the inbred lines themselves and on their performance in top and line crosses.

Reproductive performance of the inbred lines over these four years has been found to decline generally with increased inbreeding. However, certain lines having 35 - 45% inbreeding perform at a rate equal to or better than lines with 10 - 24% less inbreeding. Among the inbred lines, the correlation between reproductive rate and overall merit is less than 0.5. However, it is slightly higher between reproductive rate and weanling merit than it is between reproductive rate and yearling merit. The correlation between line ranking in weanling and yearling overall merit is also less than 0.5. This is also true of the correlation between the rank of the inbred line, and topcross and line cross performance. Thus, it is evident that considerable variation exists between the inbred lines, topcrosses and line crosses in reproductive, weanling, and yearling performance. In evaluating this performance the two factors which should receive most emphasis are amount of inbreeding and reproductive rate. (AH 1-5, 14)

#### PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

##### Genetics and Interrelations of Performance Traits

- Eltawil, Esam A. 1965. Genetic and environmental factors of sheep under arid conditions. Ph.D. Thesis, Iowa State University. (AH 1-10,11,12)
- Ercanbrack, S. K. 1965. Repeatabilities of annual fleece and body records of rams. J. Anim. Sci. 24(3): Abstract. (AH 1-6)

##### Related Publications of State Experiment Stations

- Botkins, M. P. and Paules, Leon. 1965. Crossbred Ewes Compared with Ewes of Parent Breeds for Wool and Lamb Production. J. Animal Sci. 24(4): 1111-1116  
Wyoming
- Galal, E. S. E., Cartwright, T. C. and Shelton, Maurice. 1965. Relationships Among Weights and Linear Measurements in Sheep and Heritability Estimates of Some of These Measurements. J. Animal Sci. 24(2):388-391.  
Texas
- Knight, Arlin D. and Foote, W. C. 1965. Influence of Breed Type, Feed Level, and Sex on Lamb Carcass Characteristics. J. Animal Sci. 24(3): 786-789  
Utah
- Osman, A. H. and Bradford, G. E. 1965. Effects of Environment on Phenotypic and Genetic Variation in Sheep. J. Animal Sci. 24(3):766-774  
Calif.



## AREA NO. 15: SHEEP AND GOATS - PHYSIOLOGY

Problem. Inefficient growth and reproductive failures are costly to sheep producers and cause large reductions in efficiency of production. Additional information is needed on the causes of reproductive failures in the female and low fertility or sterility in the male. Also more information is needed regarding the basic physiological processes involved in growth and reproduction. The normal physiology of all phases of growth and reproduction must be more thoroughly defined along with the effects of important genetic and environmental factors such as breed, age, season, and level of nutrition in order to develop more effective ways of increasing efficiency. Basic information is also needed concerning the development and growth of fiber follicles in order that further improved practices can be developed for wool and mohair production. This research requires studies on the nature and sequence of histological, cytological, and physiological processes involved in fiber follicle initiation and development.

### USDA AND COOPERATIVE PROGRAM

This is a continuing program conducted by physiologists and histologists on basic and applied studies of the physiology of reproduction, growth, and development of sheep and goats, including processes involved in fiber follicle initiation and development. Factors influencing mating behavior, estrus, ovulation, and embryonic development in ewes and mating behavior and fertility of rams are directed toward a more complete understanding of the reproductive processes in sheep. The work is in progress at Beltsville, Maryland; Dubois, Idaho; and cooperatively with Idaho and Oklahoma State Agricultural Experiment Stations. Environmental factors affecting growth and development are being studied in cooperation with three State experiment stations. One study contributes to the Western regional project W-46 on the effects of environmental stresses on range cattle and sheep production. Studies on fiber and follicle development of sheep and goats are in progress at Beltsville, Maryland, in cooperation with the Texas Agricultural Experiment Station.

The Federal scientific effort devoted to research in this area totals 1.4 scientific man-years. Of this number 1.0 are devoted to physiology of reproduction, 0.1 to environmental physiology, and 0.3 to physiology of wool and fiber.

### PROGRAM OF STATE EXPERIMENT STATIONS

The total research effort on sheep and goat physiology by State agricultural experiment stations is 11.7 scientific man-years.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Physiology of Reproduction

1. Synchronization of estrus and ovulation response in ewes.

Synchronization of estrus with two different oral progestogens was investigated at Dubois, Idaho. MAP (6-methyl-17 acetoxyprogesterone) and MGA (melengestrol acetate) were incorporated into alfalfa pellets and fed at the rate of 60 mg/head/day (MAP) and .25 or .30 mg/head/day (MGA) in 3/4 lb. of pellets. One-fifth of the ewes served as controls. Fifty-four to 63 yearlings and two-year-old ewes were placed with each of 20 fertile rams at the beginning of the second post-treatment estrus. The percent of ewes detected in estrus during a six-day interval for the four treatment groups (MAP, 60 mg; MGA, .25 mg; MGA, .30 mg; control) were 85, 81, 85, and 52, respectively. The percentages of ewes lambing from this estrus period were 62, 58, 64, and 47, respectively. All of the above percentages probably would have been higher had fewer ewes been placed with each ram.

At Dubois, Idaho, 65 mature ewes were used to study seasonal effects and progesterone synchronization on ovulation rate. Season-of-year differences were statistically significant. The number of corpora lutea per ewe showed a steady decline from 1.86 to 1.14 during the period September through February when monthly observations were made. The interaction of progesterone treatment with observation periods, however, was not significant. The overall difference in ovulation rate between control and progesterone-treated ewes was 1.71 vs. 1.56. Repeatability of ovulation rate within ewes and periods was significant, indicating that within periods ewes tend to ovulate the same number of ova.

The effect of hormonal augmentation of fecundity following estrual synchronization was studied on 50 ewes at Dubois, Idaho. Daily injections of progesterone for 13 days were followed by injection of 1000 i.u. of PMS to 10 ewes each on days 14, 15, 28, 29, and 30, respectively. Ten untreated ewes served as controls. Injections of PMS on days 28 to 30 gave ovulation rates of 6.6 - 10.2 (corpora lutea) as compared to 2.3 to 5.0 for days 14 and 15 and 1.6 for controls. Respective numbers of embryos per pregnant ewe were 3.0 to 3.6, 1.2 to 2.0, and 1.5. The percent of ewes pregnant of ewes treated varied from 30 to 60% and may have been reduced by the observations made by laparotomy.

Six injections of 1000 i.u. of PMS were given to ewes over a 6-month period at Dubois, Idaho. The ovulation rate in this group declined from 3.93 to 0.86 corpora lutea per ewe. The control group produced 3.40 corpora lutea per ewe after one injection of 1000 i.u. of PMS administered during the last month of the experiment. The results indicate that the ewe develops at least a temporary refractoriness to PMS following the injection of 4000 - 6000 i.u. of PMS. (AH b1-7)



2. Ovulation rate as an index of reproductive performance. The relationship of ovulation rate at one estrus to ovulation rate about 35 days later was studied in mature ewes at Dubois, Idaho, by means of laparotomy. Ewes which had 1, 2, 3, and 4 corpora lutea in early October, averaged 1.65, 1.96, 2.21, and 2.50 corpora lutea, respectively, approximately 35 days later ( $P < .01$ ). These same ewes were bred before the second observation and the average number of embryos per ewe and per pregnant ewe at 23 - 31 days post-breeding were 1.13, 1.35, 1.24, 2.00, and 1.45, 1.70, 1.80, and 2.00 for the groups which had 1, 2, 3, and 4 corpora lutea per ewe in October, respectively ( $P < .05$ ). Each of 187 ewes out of a total of 343 ewes had 4 consecutive opportunities to lamb for a total of 748 ewe years. The number of ewes in this group having an average of 1 corpora lutea or fewer, 1.5, 2.0, and 2.5 or more corpora lutea for the two laparotomy observations were 20, 46, 91, and 30, respectively. The number of lambs born per ewe for the four groups were: 1.26, 1.34, 1.48, and 1.56 ( $P < .01$ ). The average number of lambs born per ewe lambing in these same groups were 1.28, 1.43, 1.56, and 1.64, respectively. The data indicate a relationship of ovulation rate from two observations to life-time lamb production. (AH b1-7)

3. Pregnancy diagnosis in sheep and goats. Pregnancy was diagnosed and number of live embryos were predicted from laparotomy of ewes 16 - 31 days after breeding at Dubois, Idaho. The number of corpora lutea, the appearance of the amnionic vesicles and chorionic fluid, and the normalcy of the conceptus, if present, were used as criteria. Of the 136 ewes diagnosed pregnant, 98.5% had live normal embryos. The numbers of ewes predicted to have 0, 1, 2, and 3 live embryos were 5, 60, 72, and 4, respectively. The predictive accuracy in the same order was 90%, 92%, and 50%. The number of live embryos per ewe in the groups predicted to have 0, 1, 2, and 3 live embryos were 0.14, 1.05, 1.90, and 2.50, respectively. A part of the predictive error resulted from dead embryos with well developed membranes. This research shows that practical diagnosis of pregnancy and determination of number of embryos may be made with sheep with high accuracy within the first month of pregnancy. (AH b1-7)

A non-surgical procedure, using an ultrasonic analyzer, has been developed at Beltsville, Maryland, for the detection of pregnancy in sheep and goats. Results on 385 head of ewes indicate that pregnancy can be detected within 60 days of conception with an accuracy of about 95%. Results on 35 head of does show the accuracy to be 100% at 60 or more days after conception. No damage to the fetus has occurred. (AH b3-12, AH b4-3)

4. Induction of fertile estrus in lactating and dry anestrus ewes using oral progestogens and repeated PMS treatment. Mature and aged ewes were used to determine the effects of progestogens CAP AND MAP, and PMS on fertility in lactating and non-lactating anestrus ewes. The kind of progestogen had no effect on percent of ewes in estrus and percent lambing to anestrus breeding. Also, the non-lactating ewes proved no more fertile than the lactating ewes. However, of those ewes which received progestogen for 14 days before the first PMS was given, 59% lambled as compared to 42% of those which received progestogen for only 3 days before the first PMS.

The average number of lambs surviving to 2 weeks of age per ewe treated were .75 and .40 for the two treatments, respectively. (AH bl-7)

5. Effects of hormonal therapy on postpartum interval during the breeding season. Various combinations of hormones were administered to ewes at about 3 weeks after lambing in early September, 1965, at Dubois, Idaho. Four intramuscular injections of 20 mg. progesterone at 2-day intervals followed by 3 mg. estradiol 17 appeared to be more effective than the same dosage of progesterone followed by .75 mg. estradiol, 1000 i.u. PMS or 1 r.u. ovine pituitary extract. Sixty-seven percent of the 3 mg.estradiol treated group lambed again within 7 months of the fall lambing compared with 44 percent of the untreated controls. (AH bl-7)

6. Effect of teasing on mating and lambing performance of spring-bred ewes. At Fort Reno, Oklahoma, in cooperation with the Oklahoma Agricultural Experiment Station, about one-half of the flock of 315 ewes was teased with vasectomized rams for 8 days, beginning 16 days before the 1965 (May 21-June 29) breeding season. The other half served as a control. Teasing before breeding brought about the occurrence of estrus in most of the ewes during the early part of the breeding season. The teased ewes mated earlier and within a shorter period than the control ewes. Relatively more teased ewes had fertile matings during the early part of the breeding season than control ewes. However, lambing rate was higher for the control ewes, which indicates that teasing had no beneficial effect on lambing rate and may have actually decreased it. In both groups, conception rate was lowest at the beginning of the breeding season. Lambing rate was highest for ewes that conceived from matings that occurred during the early part of the season. Also lambing rate was highest for ewes that conceived from their first mating compared to ewes that conceived to return matings. (AH b3-7)

7. Estrus control in farm sheep. The breeding flock at Beltsville was divided into three groups prior to breeding to test the use of estrus synchronization and thus permit more efficient management at lambing time. One group was fed an oral progesterone (MAP), another group was exposed to vasectomized rams, and a third group served as a control. The percentage of ewes lambing in the first half of the lambing period (57%) was the same for the hormone treated group and the controls, although the hormone treated ewes showed a higher frequency in a one week period. More of the ewes exposed to vasectomized rams (76%) lambed in the first half of the period. (AH bl-8)



PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Physiology of Reproduction

- Foote, W. C. and Hulet, C. V. 1966. Ovarian response to PMS and 17-B-oestradiol in progesterone-treated ewes. J. Reprod. & Fertility 11(1): 51-56. (AH b1-7)
- Hulet, C. V., Frank, F. W., Ercanbrack, S. K., Kuttler, A. K., and Meinershagen, W. A. 1965. Observations on lambing performance of sheep vaccinated against ovine viral abortion. Am. J. Vet. Res. 26: 1464-1466. (AH b1-7)
- Hulet, C. V. 1966. Effects of various treatments with 6-methyl-17-acetoxypregesterone (MAP) on subsequent fertility in ewes. J. Reprod. & Fertility 11(2): 283-286. (AH b1-7)
- Hulet, C. V. 1966. Behavioral, social and psychological factors affecting mating time and breeding efficiency in sheep. J. Anim. Sci. 25 (supplement): 5-16. (AH b1-7)
- Hulet, C. V. and Foote, W. C. 1966. Predicting number of live embryos in the ewe by laparotomy. J. Anim. Sci. 25(2): 584 (abstr.). Proc. West. Sect. Am. Soc. Anim. Sci. 17: 67-71. (AH b1-7)
- Dermody, W. C., Foote, W. C. and Hulet, C. V. 1966. Effects of season of year and progesterone synchronization on ovulation rate. Proc. West. Sect. Am. Soc. Anim. Sci. 17: 85-90. (AH b1-7)
- Ovejera, A. A., Whiteman, J. V., Gould, M. B. and Thrift, F. A. 1966. Effects of teasing on mating and lambing performance of spring-bred ewes. Oklahoma Agricultural Experiment Station 40th Annual Livestock Feeders' Day Report, Misc. Publ. 78, pp. 34-37. (AH b3-7)

### Related Publications of State Experiment Stations

- Borgman, R. F., Edwards, R. L., Godley, W. C. and Moore, S. L.  
1965. Muscular Dystrophy in Early Weaned Lambs.  
South Carolina Agr. Expt. Sta. Tech. Bul. 1018 S.Car.
- Borgman, R. F., Edwards, R. L., Godley, W. C. and Moore, S. L.  
1965. Effects of Early Weaning, Rations and Other Treatments on  
Muscular Dystrophy in Lambs.  
Vet. Med. Sept., p. 952 S.Car.
- Dziuk, P. J. and Dickmann, Z. 1965. Sperm Penetration through the  
Zona Pellucida of the Sheep Egg.  
J. Exptl. Zool. 158:237 Ill.
- Hulet, C. V., Foote, W. C. and Blackwell, R. L. 1965. The  
Relationship of Semen Quality and Fertility in the Ram to Lamb  
Production in the Ewe.  
J. Reprod. and Fertil. 9:311 Utah
- Manns, J. G. and Boda, J. M. 1965. Effects of Ovine Growth  
Hormone and Prolactin on Blood Glucose, Serum Insulin, Plasma  
Nonesterified Fatty Acids and Amino Nitrogen in Sheep.  
Endocrinology 76:1109-1114 Calif.
- Perkins, J. L., Goode, L., Wilder, W. A., Jr. and Henson, D. B.  
1965. Collection of Secretions from the Oviduct and Uterus of  
the Ewe.  
J. Anim. Sci. 24:383 N.C.
- Ricketts, G. E., Bell, D. S., Johnson, R. R. and Moxon, A. L.  
1965. Iron and Vitamin A as Treatments in the Nutrition of New  
Born Lambs.  
J. Anim. Sci. 24(3):748 Ohio



## AREA NO. 16: SHEEP AND GOATS - NUTRITION AND MANAGEMENT

Problem. The cost of feed is the largest single expense in the production of lamb meat and wool. Information that would increase the efficiency of feed utilization, reduce feed costs, and increase productivity through better feeding practices would help the sheep producer meet the cost-price squeeze. Such information will come from basic studies of the development and function of the rumen, together with an understanding of how nutrients are metabolized in the animal. Such an understanding will enable sheep producers to modify and supplement rations in ways that will result in maximum production of desirable meat and wool. Much of the success or failure of sheep enterprises depends on production practices. Producers need better methods of animal management for the reduction of lamb mortality and disease and parasite losses, also procedures for handling ewes during breeding, gestation and lactation, as well as other labor-saving procedures and devices for the routine handling of sheep.

### USDA AND COOPERATIVE PROGRAM

This is a continuing program conducted by biochemists, nutritionists, and animal husbandmen, involving basic nutrition and ruminant physiology studies, as well as application of known and new principles, in the development of better and more economic feeding practices of farm and range sheep. Basic studies on physiology and feeding practices and known and new principles in a number of fields are applied to the development of more productive management practices for farm and range sheep. These programs are carried on at Beltsville, Maryland; Dubois, Idaho, and College Station, Texas, in cooperation with other Divisions of ARS, and in formal and informal cooperation with State Agricultural Experiment Stations of Delaware, Idaho, Maryland, Montana, Oklahoma, Texas, and Utah.

The Federal scientific effort devoted to research in this area totals 3.2 scientific man-years. Of this number, 1.3 are devoted to digestion and metabolism, 0.5 to forage evaluation and utilization, 1.0 to range and pasture management, and 0.4 to management practices, equipment, and facilities.

There are four grants involving Public Law 480 funds in foreign countries involving research on nutrition and management of sheep and goats. Two are with the Hebrew University of Jerusalem, and provide for (1) studies on the utilization of different kinds of protein feeds by ruminants at Rehovot, Israel, and supported for four years (1965-68) by \$89,927 equivalent in Israeli pounds, and (2) studies of the carbohydrate and fat economy of lactating sheep with particular reference to ketosis at the Hadassah Medical School and supported for three years (1965-68) by \$57,960 equivalent in Israeli pounds.

A project on the effects of feeding and management on white muscle disease in lambs at the Ankara University, Ankara, Turkey, is supported for five years (1963-68) by \$9,333 equivalent in Turkish lire.

A project at the Balwant Rajput College, Agra, Uttar Pradesh, India, involves investigations on milk and meat potentialities of Indian goats. Support is for five years (1965-70) by \$100,487 equivalent in Indian rupees.

#### PROGRAM OF STATE EXPERIMENT STATIONS

The total research effort on sheep and goat nutrition and management by State agricultural experiment stations is 40.0 scientific man-years.

#### PROGRESS -- USDA AND COOPERATIVE PROGRAMS

##### A. Digestion and Metabolism

1. Metabolic disorders. Studies on factors affecting urinary calculi formation in wether lambs were continued at College Station, Texas, using a calculogenic and a non-calculogenic diet. Level of physical activity had no effect on the incidence of calculi during a 112 day feeding trial. However, restriction of activity decreased feed consumption, rate of gain and feed efficiency. These effects were more pronounced when the lambs were fed the calculogenic diet. Lambs that had been confined for the 112 day period, experienced difficulty in walking and displayed muscular tremors when released. This effect was much more pronounced in the lambs fed the calculogenic diet. Recovery of mobility also was considerably slower for the lambs receiving the calculogenic diet. (AH d2-31)

Studies on some aspects of carbohydrate and fat utilization of lactating sheep (in reference to ketosis) have been initiated at Hadassah Medical School in Israel. A reciprocal relationship was found between blood glucose and plasma free fatty acid levels; as blood glucose diminished plasma free fatty acids increased. Blood glucose levels decreased and plasma free fatty acids also increased with an increase in milk production. Adrenaline injection resulted in different responses between fasted and non-fasted sheep. The free fatty acid level increase was more rapid and of greater magnitude in<sup>h</sup> fasted than in non-fasted sheep. Conversely, the glucose increment was more rapid in the non-fasted sheep but was of shorter duration. (A10-AH-16-Israel)

Studies have been continued at Ankara, Turkey, on white muscle disease of lambs. The incidence of white muscle disease was very low, during the year in the control flocks as well as in those treated with vitamin E. Oral administration of vitamin E to pregnant ewes had no effect on the live weight of the lamb at birth. (A22-AH-2-Turkey)

2. Feeding practices and procedures. Practices, for the prevention of wood chewing by sheep receiving a basic diet of alfalfa pellets, have been evaluated at Beltsville, Maryland. Feeding of 0.5 lb. of alfalfa hay,



grass hay or peanut hulls per animal every other day (along with the basic diet of alfalfa pellets) prevented wood chewing in all cases. Alfalfa hay, grass hay and peanut hulls were equally effective. (AH b2-5)

Observations (over a 3-year period) have been made on sheep that have received (1) limited amounts of alfalfa hay pellets; (2) limited amounts of a concentrate and chopped hay mixture; (3) alfalfa hay pellets ad libitum, and (4) a concentrate and chopped hay mixture ad libitum. Each group contained 15 head of yearling crossbred wethers at the start of the experiment. Average weights of the animals after 3 years were 219, 207, 247, and 252 lb., respectively, for the four groups. Death losses have been 3, 2, 4, and 1, respectively. Liver pathology has been observed in all animals that have died. (AH b2-5)

In nitrogen balance studies conducted in Israel, proteins of alfalfa hay were found to be superior to proteins of soybean meal, for growing and mature rams. Rumen ammonia levels were higher on the alfalfa diet. Addition of starch to the diets had little effect on nitrogen balance. Dietary protein level had little effect on hepatic levels of arginase and xanthine oxidase. (A10-AH-8-Israel)

Gastrointestinal fill of sheep was studied at Beltsville, Maryland. The effects of two diets (ground alfalfa or a mixed diet of alfalfa and barley), two physical forms (ground or pelleted), two levels of intake (maintenance or ad libitum), and two shrink times (24 or 48 hours) were studied in a factorial experiment with 48 mature wethers. Diet had no significant effect on rumeno-reticular, omasal-abomasal and intestinal fill nor on any compartmental weight. Rumen pH was significantly lower on the alfalfa-barley diet. Physical form had no significant effect on compartmental fill but did affect the weight of the reticulo-rumen. Level of intake significantly affected intestinal fill and intestinal tissue weight. Shrink time significantly affected the fill of all compartments and the weights of the reticulo-rumen and omasum-abomasum. Rumen buffering capacity and the percentage of dry matter of the reticulo-rumen contents were significantly reduced by increasing shrink time. (AH b2-7)

Influence of frequency and source of protein supplementation on energy metabolism of feeder lambs, receiving a basal diet containing 9.19% total protein, was studied at the New Mexico Agricultural Experimental Station. Protein supplementation significantly increased the rate of gain of the lambs. There were no significant differences between supplements (dehydrated alfalfa and cottonseed meal) in growth response or carcass data. Growth response and carcass quality also were not affected by feeding the protein supplement at 1, 7, 14, and 21 day intervals. Wethers utilized the energy of the diet more efficiently and gained at a faster rate than ewe lambs. (AH b1-10,11,12)

A diet containing 95% concentrates was compared with one containing 55% concentrates for the nutrition and growth of young lambs at the Oklahoma Agricultural Experiment Station. Although the lambs fed the high concentrate diet gained slightly faster, required less feed per lb. of gain, and had higher dressing percentages, the average pound of lean meat produced, and the pound of TDN required to produce a pound of acceptable lean meat were essentially the same for both groups. (AH b3-7)

3. Studies on nutritive requirements of sheep. Effects of variation in nutrient intake at breeding on reproductive performances of ewes was investigated at Dubois, Idaho. Three levels of nutrition (75%, 100%, and 150% of National Research Council recommendations) in the form of alfalfa pellets given before breeding had no significant effect on ovulation rate or embryo survival. Post-treatment ovulation rate of ewes on the 75% level decreased from 189% to 184%. Ovulation rate increased 8 and 33 percentage points on the 100% and 150% levels, respectively. Normal embryos per ewe bred is a measure of the combined effect of ovulation rate and normal embryo per corpus luteum. Percent normal embryos per ewe bred was 150%, 159%, and 183% for the 75%, 100%, and 150% levels, respectively. While not statistically significant, these differences could be important economically. (AH b3-9)

Observations on maintenance requirements of wether sheep kept under ordinary barn conditions have been continued at Beltsville, Maryland. The maintenance requirement was  $50.0 \pm 0.6$  gm/day/wt.  $0.75$  kg. of air-dry alfalfa. This was not significantly different from the previous year. Maintenance requirements appear to decline slightly with advancing age. (AH b2-7)

## B. Forage Evaluation and Utilization

1. Forage evaluation. Chemung crownvetch hay was compared with alfalfa hay in a feeding trial with lambs at Beltsville, Maryland. The crownvetch was cut June 1, 1965, and partially field cured. Curing was completed under forced hot air (160°F). The hays were fed ad libitum in both coarsely ground and pelleted forms over a 70-day period. Average daily gains on the ground alfalfa and crownvetch hays were 0.22 and 0.14 lb.; the corresponding values for the pelleted hays were 0.32 and 0.26 lb., respectively. Physical form, but not forage species, affected forage consumption; the means were 88 and 107 gm. of ground and pelleted forage/day/wt.  $0.75$  kg., respectively. Apparent digestibility of the crownvetch hay was lower than for the alfalfa. (AH b2-7)

Grazing trials were conducted on crownvetch at Beltsville, Maryland. Crossbred western wethers were used to stock experimental plots at three levels of grazing intensity. During a 94-day period (May 13 to July 20, 1966) the overall rates of gain were low (0.20 lb/day) with the average stocking rate ranging from 9 to 14 sheep per acre. Most of the available forage was produced by early June. Many of the lambs appeared unthrifty near the end of the experiment and there were 4 death losses. Necropsy examination of 10 animals revealed a flabbiness of the ventricular musculature



without any sign of gross deterioration of the heart. Investigations are underway to determine if the cardiac symptoms resulted from biochemical constituents of the crownvetch or from parasite infestation. (AH b2-7)

C. Range and Pasture Management

1. Effect of grazing sagebrush-grass range during summer. Although the sagebrush-grass country has traditionally been considered to be spring-fall range for sheep, summer use of the ranges is being explored in cooperation with the Forest Service at Dubois, Idaho. Lambs were weaned at about 85 days of age and placed into the feedlot while the ewes were placed on sagebrush-grass range. Two intensities of summer-grazing were used (28 and 45 sheep days per acre). In 5 years of summer grazing, grasses decreased in yield (23%), forbs increased (118%) and small shrubs decreased (40%). Large shrubs, including sagebrush, remained unchanged. The decline in yield of perennial grasses and small shrubs could have been caused by the impact of summer grazing. The increase of forbs may have been influenced by weather or a favorable competitive status with grasses, after the latter were weakened by grazing. (AH b3-1)

D. Management Practices, Equipment and Facilities

1. Early weaning of range lambs. Performance of lambs weaned early (83 days) were compared with those weaned normally at 126 days of age, at Dubois, Idaho. Early weaned lambs gained 20.8 lb. during the next 43 days compared with 23.0 lb. for the non-weaned lambs. The non-weaned lambs grazed with their dams on summer range while the weaned lambs were self-fed pellets in drylot for 20 days and then self-fed pellets on pasture for 23 days. The early weaned lambs gained more efficiently in drylot than when self-fed on pasture. (AH b3-9)

2. Management of lambs on pasture in relationship to parasitism. Two groups of lambs weaned at an average age of 85 days were grazed on two types of pastures at Beltsville, Maryland. One group was allotted pastures that had been grazed in previous years by parasite infested sheep and the other group was allotted "clean" pastures. Both groups received creep feed and were given a therapeutic dose of phenothiazine, followed in 2 weeks by thiabendazole in early July. The average hematocrit values for the 2 groups were 32.4 and 33.4, in late August, which is in the normal range for lambs with low infestations of Haemonchus contortus. (AH b3-11)

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Digestion and Metabolism

Crookshank, H. R., Packett, L. V., Jr., and Kunkel, H. O. 1965. Ovine urinary calculi and pelleted rations. J. Anim. Sci. 24(3): 638-42. (AH d2-31)

Feeding Practices and Procedures

Lindahl, Ivan L., and Reynolds, P. J. 1965. Some physiological effects of feeding pellets to sheep. Proc. of Conf. on Rumen Function, December, 1965. (AH b2-5)

Noble, Robert L., Walters, L. E., Tillman, A. D. and Nelson, Eldon. 1966. Optimum nutrition of young lambs for maximum growth and lean production. Oklahoma Agricultural Experiment Station 40th Annual Livestock Feeders' Day Report, Misc. Publ. 78, pp. 79-82. (AH b3-7)

Management Practices, Equipment and Facilities

Lindahl, Ivan L., Jackson, Charlie, Jr., Colglazier, M. L., and Kerns, Paul. 1965. Performance of lambs fed green soilage compared with lambs on pasture. J. Anim. Sci. 24: 1217 (Abst.) (AH b3-11)

Lindahl, Ivan L., Colglazier, M.L., and Jackson, Charlie, Jr. 1966. Performance of lambs fed green chop vs. lambs on pasture. The Shepherd 11(3). March. Sheep Breeder and Sheepman 86(3): March. (AH b3-11)

Lindahl, Ivan L. 1966. A dairy goat for home milk production. USDA Leaflet No. 538. (AH b4-3)

Sidwell, G. M. 1966. Raising a small flock of sheep. USDA Farmers' Bulletin No. 2222. (AH b1-1, 2, 3)



Related Publications of State Experiment Stations

- Bell, T. D., Dahmen, J. J., Baker, J. P. and Sharp, G. D. 1965.  
Value of Supplemental Vitamin A for Young Lambs.  
Ida. Agr. Res. Bul. 67. Idaho
- Bensadoun, A. and Reid, J. T. 1965.  
Effect of Physical Form, Composition and Level of Intake of Diet on the  
Fatty Acid Composition of the Sheep Carcass.  
J. Nutrition 87:239-244. New York
- Bhattacharya, A. N. and Fontenot, J. P. 1965.  
Utilization of Different Levels of Poultry Litter Nitrogen by Sheep.  
J. Animal Sci. 24(4):1174-1178. Virginia
- Bushman, D. H., Emerick, R. J. and Embry, L. B. 1965.  
Experimentally Induced Ovine Phosphatic Urolithiasis: Relationships  
Involving Dietary Calcium, Phosphorus and Magnesium.  
J. Nutrition 87:499-504. South Dakota
- Bushman, D. H., Emerick, R. J. and Embry, L. B. 1965.  
Incidence of Urinary Calculi in Sheep as Affected by Various Dietary  
Phosphates.  
J. Animal Sci. 24(2):671-675. South Dakota
- Chicco, C. F., Ammerman, C. B., Moore, J. E., Van Wallegham, P. A.  
Arrington, L. R. and Shirley, R. L. 1965.  
Utilization of Inorganic Ortho-Meta- and Pyrophosphates by Lambs and  
by Cellulolytic Rumen Microorganisms In Vitro.  
J. Animal Sci. 24(2):355-363. Florida
- Christiansen, W. C., Kawashima, R. and Burroughs, W. 1965.  
Influence of Protozoa Upon Rumen Acid Production and Liveweight Gains  
in Lambs.  
J. Animal Sci. 24(3):730-734. Iowa
- Cook, C. W., Kothman, M., and Harris, L. E. 1965.  
Effect of Range Condition and Utilization on Nutritive Intake of Sheep  
on Summer Ranges.  
J. Range Mgt. 18(2):69-73. Utah
- Crookshank, H. R., Packett, L. V. Jr. and Kunkel, H. O. 1965.  
Ovine Urinary Calculi and Pelleted Rations.  
J. Animal Sci. 24(2):638-642. Texas
- Danke, R. J., Panciera, R. J. and Tillman, A. D. 1965.  
Gossypol Toxicity Studies With Sheep.  
J. Animal Sci. 24(4):1199-1201. Oklahoma

- Davison, K. L., McEntee, K. and Wright, M. J. 1965.  
Responses of Pregnant Ewes Fed Forages Containing Various Levels of Nitrate.  
J. Dairy Sci. 48(7):968-977. New York
- Elliot, J. M., Hogue, D. E., Meyers, G. S., Jr. and Loosli, J. K. 1965.  
Effect of Acetate and Propionate on the Utilization of Energy by Growing-Fattening Lambs.  
J. Nutrition 87:233-238. New York
- Fontenot, J. P. and Hopkins, H. A. 1965.  
Effect of Physical Form of Different Parts of Lamb Fattening Rations on Feedlot Performance and Digestibility.  
J. Animal Sci. 24(1):62-68. Virginia
- Glimp, H. A. and Tillman, A. D. 1965.  
Effect of Jackbean Urease Injections on Performance, Anti-Urease Production and Plasma Ammonia and Urea Levels in Sheep.  
J. Animal Sci. 24(1):105-112. Oklahoma
- Haenlein, G. F. W. and Holdren, R. D. 1965.  
Response of Sheep to Wafered Hay Having Different Physical Characteristics.  
J. Animal Sci. 24(3):810-818. Delaware
- Ingalls, J. R., Thomas, J. W., Benne, E. J. and Tesar, M. 1965.  
Comparative Response of Wether Lambs to Several Cuttings of Alfalfa, Birdsfoot Trefoil, Bromegrass and Reed Canarygrass.  
J. Animal Sci. 24(4):1159-1164. Michigan
- Johnston, W. K. Jr., Anglemier, A. F., Fox, C. W. Oldfield, J. A. and Sather, Lois A. 1965.  
Effects of Coumestrol and Diethylstilbestrol on the Organoleptic Quality of Lamb.  
J. Animal Sci. 24(3):718-721. Oregon
- Jordan, R. M. 1965.  
Effect of Heat-Processed Flaked Corn on Growth of Lambs.  
J. Animal Sci. 24(3): 754-756. Minnesota
- Jordan, R. M. and Marten, G. C. 1965.  
Effect of Grazing Management of Annual Pastures on Body Weight and Subsequent Wool and Lamb Production of Non-lactating Ewes.  
J. Animal Sci. 24(2):476-479. Minnesota
- Karr, M. R., Garrigus, U. S., Hatfield, E. E. and Norton, H. W. 1965.  
Factors Affecting the Utilization of Nitrogen From Different Sources by Lambs.  
J. Animal Sci. 24(2):459-468. Illinois



- Karr, M. R., Garrigus, U. S., Hatfield, E. E., Norton, H. W. and Doane, B. B. 1965.  
Nutritional and Chemical Evaluation of Urea and of Biuret in Complete Ensiled Finishing Diets by Lambs.  
J. Animal Sci. 24(2):469-475. Illinois
- Lawlor, M. J., Smith, W. H. and Beeson, W. M. 1965.  
Iron Requirement of the Growing Lamb.  
J. Animal Sci. 24(3):742-747. Indiana
- Matrone, G., Bunn, C. R. and McNeill, J. J. 1965.  
Study of Purified Diets for Growth and Reproduction of the Ruminant.  
J. Nutrition 86(2):154-158. North Carolina.
- Mayfield, E. D., Smith, J. L. and Johnson, B. C. 1965.  
Metabolism of Acetate by Sheep Liver Homogenates.  
J. Dairy Sci. 48(1):93-98. Illinois
- McLaren, G. A., Anderson, G. C. and Barth, K. M. 1965.  
Influence of Methionine and Tryptophan on Nitrogen Utilization by Lambs Fed High Levels of Non-Protein Nitrogen.  
J. Animal Sci. 24(1):231-234. West Virginia
- McLaren, G. A., Anderson, G. C. and Barth, K. M. 1965.  
Influence of Folic Acid, Vitamin B<sub>12</sub> and Creatine on Nitrogen Utilization by Lambs Fed High Levels of Non-Protein Nitrogen.  
J. Animal Sci. 24(2):329-332. West Virginia
- McLaren, G. A., Anderson, G. C., Tsai, L. I. and Barth, K. M. 1965.  
Levels of Readily Fermentable Carbohydrates and Adaptation of Lambs to All Urea Supplemented Rations.  
J. Nutrition 87:331-336. West Virginia
- Morris, J. G., Harris, L. E., Butcher, J. E. and Cook, C. W. 1965.  
Indices of Efficiency of Rumen Fermentation of Sheep Grazing Desert Range Forage as Influenced by Supplements of Nitrogen and Phosphorus.  
J. Animal Science 24(4):1152-1158. Utah
- Ott, E. A., Smith, W. H., Stob, M., Parker, H. E., Harrington, R. B. and Beeson, W. M. 1965.  
Zinc Requirement of the Growing Lamb Fed a Purified Diet.  
J. Nutrition 87(4):459-463. Indiana
- Packett, L. V. and Groves, T. D. D. 1965.  
Urea Recycling in the Ovine.  
J. Animal Sci. 24(2):341-346. Indiana
- Picketts, G. E., Bell, D. S., Johnson, R. R. and Moxon, A. L. 1965.  
Iron and Vitamin A as Treatments in the Nutrition of Newborn Lambs.  
J. Animal Sci. 24(3):748-753. Ohio

Robbins, T. D., Kunkel, H. O. and Crookshank, H. R. 1965.  
Relationship of Dietary Mineral Intake to Urinary Mineral Excretion and  
the Incidence of Urinary Calculi in Lambs.  
J. Animal Sci. 24(1):76-82. Texas

Tillman, A. D., Sheriha, G. M., Goodrich, R. D., Nelson, E. C. and  
Smith, G. S. 1965.  
Effect of Injected Hydroxylamine Upon Vitamin A Status of Sheep.  
J. Animal Sci. 24(4):1136-1139. Oklahoma

Tillman, A. D., Sheriha, G. M. and Sirny, R. J. 1965.  
Nitrate Reduction Studies With Sheep.  
J. Animal Sci. 24(4):1140-1146. Oklahoma

Welch, J. G., O'Connor, J. J. and Vander Noot, G. W. 1965.  
Effect of Feeding Chlorhydroxyquinoline to Fattening Lambs.  
J. Animal Sci. 24(1):38-40. New Jersey



## AREA NO. 17: SWINE--BREEDING

Problem. Improvements in the heredity of swine depend on the intensity and accuracy of selection practiced in choosing breeding animals and on the choice of a mating system that maximizes the rate of genetic improvement. Crossbreeding swine for the production of market animals has so proved its value that over 90% of the pigs marketed in the United States are currently some kind of crossbreds. Research in swine breeding thus is faced with the dual challenge of developing foundation seed stock populations that yield maximum improvement for commercial production and also devising methods that fully utilize the genetic potential of available seed stocks for further increases from heterosis and hybrid vigor generally shown by crossbred pigs. It is essential that experimental work continue the development of genetic facts and practical methods that breeders can use to develop better and more efficient seed stock strains. Particular effort is needed on effective genetic means for efficient production of pork with more lean and less fat without sacrificing gains in other production traits.

### USDA AND COOPERATIVE PROGRAM

This is a continuing program of basic and applied research conducted by geneticists and animal husbandmen to elucidate genetic principles and develop effective breeding systems that will result in further increases in the efficiency of swine with respect to productivity and carcass value. This is a coordinated research effort involving the USDA and several State agricultural experiment stations. Research is in progress at Beltsville, Maryland, cooperatively with the Montana Agricultural Experiment Station at Miles City, Montana, and at the Regional Swine Breeding Laboratory with headquarters at Ames, Iowa. The Regional Laboratory includes cooperative projects at State Agricultural Experiment Stations in Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, Nebraska, North Carolina, Oklahoma, South Dakota, and Wisconsin. Investigations on genetic principles, selection, and breeding systems include work with swine and also with laboratory animals on important performance traits, their heritabilities, and their phenotypic and genetic correlations. The results of such studies provide the basis for emphasis given to different complex traits and the underlying factors in evaluating different systems for achieving genetic changes. Traits of major interest include productivity of dam, viability, growth rate, feed efficiency, carcass composition, and quality of meat.

Cooperative research with the Food and Drug Administration is in progress to investigate the response of "miniature" swine to further reduction in body size from selection and their usefulness for toxological tests, as well as basic studies in nutrition and genetics.

A grant with the College of Agriculture, Poznan, Poland, provides for investigations on red blood cell and serum antigens to establish the mode of

inheritance and relative frequencies of these antigens in certain breeds of swine. Its duration is for 5 years (1962-1966) and involves PL-480 funds of \$4,111 per year.

The Federal scientific effort in this area totals 6.5 scientific man-years. Of this number, 1.3 are devoted to genetics and interrelations of performance traits and 5.2 to selection and breeding systems.

#### PROGRAM OF STATE EXPERIMENT STATIONS

The total research effort on swine breeding by State agricultural experiment stations is 10.4 scientific man-years.

#### PROGRESS--USDA AND COOPERATIVE PROGRAMS

##### A. Genetics and Interrelations of Performance Traits

A study of the effects of early weaning on postweaning growth rate and fatness in selected and control line Duroc and Yorkshire pigs was started during the year. One or two pigs from each of several litters were weaned at 35 days of age and compared with their littermates of the same sex weaned at 56 days. The study included 33 pairs of Duroc and 34 pairs of Yorkshire pigs. At 56 days of age early weaned pigs averaged 7.5 pounds less for Durocs and 6.9 pounds less for Yorkshires than their littermates that remained on the sow. Daily gain from 56 days to 175 pounds averaged for early and late weaned pigs 1.40 and 1.44 pounds in Durocs and 1.29 and 1.26 pounds in Yorkshires. Backfat thickness also differed only slightly between early and late weaned pigs, the respective means being 1.48 and 1.47 inches in Durocs and 1.24 and 1.20 inches in Yorkshires. (AH al-12)

Progeny records of 99 purebred boars that sired both purebred and crossbred pigs from 1955 through 1964 were used to estimate the heritability of 56-day weight, postweaning daily gain, and probed backfat thickness. The heritability estimates in the purebreds were  $0.03 \pm .06$ ,  $0.28 \pm .06$ , and  $0.55 \pm .12$ , respectively. The corresponding estimates within the crossbreds were  $0.19 \pm .09$ ,  $0.39 \pm .10$ , and  $0.47 \pm .13$ . The genetic correlations within the purebreds of 56-day weight with postweaning daily gain, of 56-day weight with backfat thickness, and of postweaning daily gain with backfat thickness were  $0.29 \pm .50$ ,  $-0.05 \pm .53$ , and  $0.07 \pm .18$ , respectively. Within the crossbreds the corresponding correlations were  $0.20 \pm .21$ ,  $0.61 \pm .16$ , and  $-0.39 \pm .18$ . Within the purebreds improvement in postweaning growth rate and probed backfat would be expected to come almost entirely from direct selection for these traits, whereas within the crossbreds it appears that postweaning daily gain may be increased by selection for either 56-day weight or lower backfat. Improvement in crossbred performance from mass selection on both sexes within the purebreds apparently would be greater for all three traits than that obtained by reciprocal selection. (AH al-8)



The sources of the improvement obtained in ham and loin percent were investigated by evaluating the relative emphasis placed in selecting boars on the basis of their own backfat probe, sib carcass data, and progeny carcass data. About 40% of the improvement could be attributed to selection based on the boar's own backfat probe and about 20% and 40% to selection based on carcass data on 2.5 full sibs and 8.5 progeny, respectively. (AH al-22)

Data collected from five generations of selection for thinner backfat in two lines of Poland China pigs gave realized heritabilities of 0.54 and 0.43 in the spring and fall lines, respectively. The heritability derived from the intrasire regression of offspring on dam was 0.41 for the two lines combined. (AH al-21)

Data on 453 litters from five lines showed that 42-day litter weaning weight was determined to a greater extent by the number of pigs weaned than by the pigs' weights. Litter size at birth had a slightly greater influence on litter size at 42 days than did survival rate, although both were important factors. Pig weight at 42 days was determined principally by the pig's weight gain and only slightly by its birth weight. Litter size at birth showed statistically significant correlations of 0.82, -0.28, 0.70, 0.50, and -0.49 with litter weight at birth, survival rate to weaning, litter size at weaning, litter weight at weaning, and pig weight at weaning. Phenotypic correlations of 0.28, 0.54, and -0.32 were obtained for pig birth weight with survival rate, pig weaning weight, and litter size at weaning. Weight loss of the dam during lactation was associated with increased litter size and litter weight and averaged 17.3 kg. There was no significant difference between sows and gilts. (AH al-8)

A study of the relation of nipple number with various maternal and pig traits, based on data from 1,004 Duroc and 1,380 Yorkshire pigs, showed correlations of -0.06, -0.22, and -0.20 between dam's nipple number and number of live pigs born, number of pigs weaned, and litter weight at weaning for Durocs, and -0.17, -0.03, and -0.03 for Yorkshires. Nipple number of the pig was not significantly related to either its birth weight or the number of pigs born in the litter. Heritability of nipple number estimated from paternal half-sib correlations was  $0.18 \pm 0.08$  for Durocs and  $1.00 \pm 0.18$  for Yorkshires. (North Carolina)

Data collected on 1,192 gilts gave heritabilities of  $0.49 \pm 0.11$  for age at puberty and  $0.52 \pm 0.08$  for weight at puberty from the regression of offspring on dam. Heritabilities estimated by the paternal half-sib method were essentially zero ( $-0.20 \pm 0.14$ ) for age at puberty and only about  $0.17 \pm 0.14$  for weight at puberty. (AH al-20)

Heritabilities of 154-day weight based on data for 8,039 purebred and crossbred pigs using paternal half-sib correlations were 0.70, 0.81, and 0.65 for purebred boars, barrows, and gilts and 0.03 and 0.00 for crossbred barrows and gilts, respectively. Other heritabilities derived from daughter-dam regressions (245 pairs) were 0.05, 0.19, and 0.29 for litter size at birth,

at 56 days of age, and at 154 days of age, respectively. Genetic correlations were -0.55 for 154-day weight with backfat probe and 0.90 for litter size at 56 days with litter size at 154 days. (North Carolina)

A study of feed requirements obtained for pigs at 14-day intervals from 84 days of age to a final weight of about 210 pounds showed none of the phenotypic correlations between individual periods and the entire period exceeding 0.44. It appears from these results that no one period or combination of periods was sufficiently high in predictive value to warrant using it in place of the entire period. (AH al-10)

Total serum cholesterol levels recorded for two lines of Poland China pigs at 180 days of age averaged 114.8 and 112.6 mg. percent for 140 spring and 148 fall farrowed pigs, respectively. The heritability of serum cholesterol level, using maternal and paternal half-sib correlations, was 0.06 and 0.16, respectively. Cholesterol level decreased with age of pig from a high at 21 days until a plateau was reached at about 90 days of age. The phenotypic correlation between cholesterol level and backfat thickness was -0.32. (AH al-21)

A study of sexual maturity in gilts of different genetic stocks is now in its fourth year. The gilts available for study in 1965 were from the same four breed groups as those studied in 1963. Age at puberty for select LL, select BB, control LL, and control BB gilts averaged 196, 180, 204, and 194 days, respectively. The ranking of the four groups agrees rather well with that for the same groups in 1963, although age at puberty averaged from 4 to 14 days less for this year's groups than for those of the earlier year. (AH al-13)

High-fat, low-fat, and control line Duroc gilts of fall 1965 farrow averaged 217, 194, and 182 days in age at puberty. The corresponding averages for high-fat, low-fat, and control line Yorkshire gilts were 214, 205, and 188 days, respectively. In both breeds the differences between the high- and low-fat lines point in the same direction as those observed in the previous year. (AH al-12)

## B. Selection and Breeding Systems

1. Selection for single traits. Selection for high and low fatness at a liveweight of about 175 pounds has been carried through 11 generations in Durocs and 9 generations in Yorkshires. Backfat thickness in 11th generation high-fat, low-fat, and control line Duroc pigs averaged 2.15, 1.04, and 1.47 inches, compared with 2.08, 1.03, and 1.44 inches in 10th generation pigs. The corresponding averages for 9th generation Yorkshire pigs were 1.56, 0.90, and 1.19 inches, compared with 1.48, 0.91, and 1.19 inches in 8th generation pigs. In the selected Duroc lines, litter size both at birth and at weaning averaged higher than in the preceding generation, while the opposite was true in the selected Yorkshire lines. (AH al-12)



Carcass data obtained on samples of pigs slaughtered at about 220 pounds continued to show rather marked differences between high- and low-fat pigs, with controls generally intermediate between the selected lines in both breeds. Eleventh generation high-fat, low-fat, and control line Durocs averaged 2.71, 1.46, and 2.12 inches in backfat thickness; 25.8, 29.5, and 28.0 inches in length of carcass; 2.77, 4.20, and 3.99 square inches in loin-eye muscle area; 34.2, 41.0, and 38.6% in yield of lean cuts; 21.4, 12.1, and 15.1% in yield of fat cuts; and 12.2, 10.6, and 11.4% in yield of bacon. Ninth generation high-fat, low-fat, and control line Yorkshire pigs averaged 2.21, 1.29, and 1.59 inches in backfat thickness; 29.2, 30.0, and 29.7 inches in length of carcass; 3.72, 4.76, and 3.88 square inches in loin-eye muscle area; 38.1, 42.9, and 40.0% in yield of lean cuts; 17.9, 10.3, and 13.6% in yield of fat cuts; and 12.4, 10.7, and 11.3% in yield of bacon. Data comparing the various lines with respect to components of right hams showed that in Durocs low-fat pigs averaged 2.9 pounds or 46% higher in weight of lean meat, and 1.4 pounds or 29% lower in weight of fat than high-fat pigs. Low-fat Yorkshire pigs showed similar though somewhat smaller advantages over high-fat Yorkshire pigs, with control line pigs being intermediate for both traits in the two breeds. In bone weight of ham, low-fat pigs exceeded high-fat pigs by 0.4 pound or by 40% in the Duroc breed and by 0.3 pound or by 27% in the Yorkshire breed. (AH al-12)

2. Selection for specific combining ability. The reciprocal recurrent selection program being conducted at Beltsville, Maryland, is now in the first phase of the sixth selection cycle. Sixth cycle BB x LL litters exceeded control LL litters by 2.6 pigs or by 34% in litter size at birth, and by 2.9 pigs or by 50% in litter size at weaning. These advantages for crosses are considerably greater than those observed in earlier cycles. Reciprocal LL x BB litters, on the other hand, were slightly inferior to control BB litters in both litter size at birth and litter size at weaning. The respective means for LL x BB litters were 8.1 and 6.7 pigs, compared with 8.8 and 7.0 pigs for BB litters. Postweaning data obtained in the second phase of the fifth cycle showed straightbred select LL and select BB litters exceeding control LL and control BB repeat litters by 15.0 and 16.5 pounds or by 9 and 10% in pig weight at 140 days, and by 0.11 and 0.17 pound or by 7 and 12% in daily gain from weaning to a final weight of about 225 pounds. Backcross pigs produced by mating single cross BL and LB gilts in various combinations to control LL and control BB boars exceeded control LL and control BB pigs by 4 and 20 pounds or by 2 and 14% in pig weight at 140 days. In postweaning daily gain, pigs out of LB gilts exceeded control BB pigs by 0.18 pound or by 13%, while pigs out of BL gilts actually averaged 0.06 pound less than control LL pigs. These results show lower advantages in favor of backcross pigs than those observed in the second phase of the fourth cycle. (AH al-13)

In the Miles City project, selection for specific combining ability was discontinued with completion of the sixth selection cycle in 1964. A third set of litters representing all possible crosses among the Montana "Select," Yorkshire "Select," and Montana "Control" strains was obtained this spring



for evaluating the effectiveness of reciprocal recurrent selection as practiced in this project. In addition, a number of backcross litters were obtained this spring from matings of single cross gilts from crosses among the three strains with boars of these strains. (AH al-11)

A study of sire components of variance and covariance for 56-day weight, postweaning daily gain, and probed backfat thickness, based on data from purebred and crossbred offspring of 99 purebred boars, showed that improvement in crossbred performance from intrapopulation mass selection on both sexes within the purebreds was greater for all three traits than that obtained by reciprocal recurrent selection. (AH al-8)

Comparison of three groups of pigs produced in a reciprocal selection program by Duroc x Yorkshire and Yorkshire x Duroc gilts with pigs produced concurrently in a conventional intrabreed mass selection program showed no significant differences for any of the productivity traits studied. Least squares analyses indicated greater effectiveness of reciprocal recurrent selection for litter sizes and weights at 21 and 154 or 84 days of age in the first two year-seasons, whereas in the third year-season the intrabreed selection group was superior to the reciprocal selection group. (AH al-10)

3. Crossbreeding and heterosis. The systematic breed-line rotation cross involving the Hampshire, Duroc, and Yorkshire breeds at Eureka, South Dakota, has been carried through 18 generations and is continuing to show a very satisfactory level of performance. (AH al-9)

4. Breed evaluation. Comparison of the Minnesota No. 1, 2, and 3 breeds of swine with representatives of the Hampshire, Poland China, and Duroc breeds showed that the Minnesota breeds grew slightly faster, had about 0.1 inch more backfat, and were about equally as efficient as the standard breeds. In individual breed performance, the Minnesota No. 1 gained most rapidly, the Minnesota No. 3 probed least, and the Minnesota No. 2 was most efficient. (AH al-17)

Carcass data from 686 pigs at one station show Hampshire continued to excel in percent ham and loin, loin-eye area, and backfat thickness. Crosses out of Duroc sows and by Yorkshire boars were somewhat fatter than the average of the two parent breeds and had less percent ham and loin and smaller loin-eye areas. The reciprocal cross resulted in considerably better carcasses, especially with respect to loin-eye area. (AH al-22)

The miniature swine breeding project at Beltsville is now in its third year. Selection is primarily for a white skin and hair coat and reduced body size. Crossbred litters from matings of 7 Hanford white males with 23 Hormel colored females exceeded straightbred litters out of 11 Hormel females by averages of 1.1 pig or 13% in litter size at birth; 2.5 pounds or 13% in pig weight at weaning; and by 16.2 pounds or 21% in pig weight at 140 days of age. Each of the Hanford boars used in the crosses sired white and colored pigs in about equal proportions.



5. Gene pools. A gene pool of older breeds has been completed. Initial selection of lines will begin in 1967. Work is under way on operating techniques, nutritional requirements, ovulation rates, and age at puberty. (AH al-20)

6. Pilot experiments. Selection for postweaning gain from 18 to 42 days of age in the mouse continues to be effective after 31 generations. Total selection response in gain was about 43% of the original population mean. This was about 70% of the predicted value. The correlated response of feed per unit of gain to selection for gain was only 59% of the response predicted. This was thought to be largely due to less response than predicted in postweaning gain itself. (AH al-17)

### C. Performance and Progeny Testing

Comparison of 154 individually-fed barrows with 128 group-fed barrows for eight performance traits showed no significant differences for any of the live animal traits or carcass weight when animals were slaughtered at the same weight. However, the individually-fed pigs had significantly longer carcasses, with a greater percent of lean cuts and less carcass backfat than the group-fed pigs. (AH al-10)

Results of swine breeding research continue to be applied in Central swine testing stations. About 1.5% of the boars used for commercial pig production in one State are tested. Seed stock herds are growing larger and becoming fewer as the task of breeding suitable seed stock becomes more technical. Most of these herds send pigs to the testing stations regularly to obtain comparable data on the performance of their pigs. (AH al-22)

Data from 1,058 pigs fed out at one swine evaluation station showed intra-litter correlations of -0.31, 0.07, 0.31, -0.42, and 0.35 for percent lean cuts with daily gain, carcass length, loin-eye area, backfat thickness, and index. Correlations of 0.41, -0.17, -0.15, and -0.24 were obtained for backfat thickness with daily gain, carcass length, loin-eye area, and index. Percent ham showed correlations of -0.21, 0.04, 0.27, 0.35, -0.27, and 0.21 with daily gain, carcass length, loin-eye area, percent lean cuts, backfat thickness, and index. (North Carolina)

A study of 422 pigs tested for learning ability in a T-maze beginning at 18 days of age showed an average of 55.2% correct responses based on five trials per day on three consecutive days. Breed and sex differences were found to be highly significant. (AH al-10)

## PUBLICATIONS--USDA AND COOPERATIVE PROGRAMS

### Genetics and Interrelations of Performance Traits

Ahlschwede, W. T. and Robison, O. W. 1965. Relationship of nipple number to maternal performance in swine. (Abs.) J. Animal Sci. 24:845.

- Biswas, D. K., Hurt, P. V., Chapman, A. B., First, N. L., and Self, H. L. 1966. Feed efficiency and carcass desirability in swine. J. Animal Sci. 25:342-347. (AH al-10)
- Gillespie, Robert P. 1966. Significance of direction of tail curl in swine. M.S. Thesis, Univ. of Mo. Libr., Columbia. (AH al-21)
- Hong, Jae Hee. 1966. Influence of heredity and other factors on leucocytes in swine. M.S. Thesis, Univ. of Mo. Libr., Columbia. (AH al-21)
- Louca, A. and Robison, O. W. 1965. Heritability and genetic correlations in swine. (Abs.) J. Animal Sci. 24:850.
- Magee, W. T. 1966. How commercial herds change genetically. Quar. Bul., Mich. Agr. Expt. Sta. 48:4. (AH al-23)
- Omtvedt, I. T., Whatley, J. A., (Jr.), and Willham, R. L. 1966. Some production factors associated with weaning records in swine. J. Animal Sci. 25:372-376. (AH al-8)
- Rahnefeld, G. W., Comstock, R. E., Boylan, W. J., and Singh, Madho. 1965. Genetic correlation between growth rate and feed per unit gain in mice. J. Animal Sci. 24:1061-1066. (AH al-17)
- Reutzel, Lawrence F. 1966. Genetic and phenotypic relationships involving age at puberty and growth rate in gilts. M.S. Thesis, Univ. of Nebr. Libr., Lincoln. (AH al-20)
- Sumption, L. J. 1966. What factors are important in carcass evaluation. Univ. of Nebr. Swine Progress Rpt. No. 377:19-21. (AH al-20)

#### Selection and Breeding Systems

- Gray, Richard Carl. 1965. Effects of five generations of selection for low backfat thickness in swine. Ph.D. Thesis, Univ. of Mo. Libr., Columbia. (AH al-21)
- Lucas, Leo E. 1966. Records - make use of them in selecting your boar. Univ. of Nebr. Swine Proj. Rpt. 377:15-16. (AH al-20)
- Omtvedt, I. T. 1965. Developing a practical swine breeding program. Proceedings of the 7th Okla. Swine Breeders Short Course, 12/10/65, Okla. City, Okla. (AH al-8)
- Omtvedt, I. T. 1966. The importance of the purebred breeder in commercial production. Okla. State Univ. Block and Bridle Club Yearbook 3:15, Stillwater. (AH al-8)



Stanislaw, C. M. 1966. A covariance analysis between purebred and crossbred populations of swine. Ph.D. Thesis, Okla. State Univ., Libr., Stillwater. (AH al-8)

Siers, David. 1966. Predicting ham and loin percent from ultrasonic measurements. M.S. Thesis, Iowa State Univ. Libr., Ames. (AH al-22)

Waltz, F. A. 1966. Linear and non-linear effects of inbreeding in swine. Ph.D. Thesis, Purdue Univ. Libr., Lafayette. (AH al-18)

#### Related Publications of State Experiment Stations

Omtvedt, I. T., Stanislaw, C. M. and Whatley, J. A., Jr. 1965. Relationship of Gestation Length, Age and Weight at Breeding, and Gestation Gain to Sow Productivity at Farrowing. J. Anim. Sci. 24(2):531-535 Okla.

Urban, W. E. and Hazel, L. N. 1965. Ultrasonic Measurements of Fattening Rate in Swine. J. Anim. Sci. 24:830-833 Iowa

## AREA NO. 18: SWINE--PHYSIOLOGY

Problem. Increased efficiency in the production of pork is dependent on the elucidation of the basic mechanisms underlying the physiology of reproduction, growth, genetics, and environment. In physiology of reproduction, significant economic gains can be made through studies which reduce the incidence of embryo death and with studies related to the development of an effective and practical program of artificial insemination.

In genetics, physiological and biochemical techniques must be utilized in order to identify lines or breeds of swine that have the inherent capacity to produce high quality lean meat more efficiently.

### USDA AND COOPERATIVE PROGRAM

This is a continuing program conducted by physiologists, biochemists, and animal husbandmen on basic and applied problems in the physiology of reproduction, artificial insemination, and the physiology of growth and development, particularly with respect to the mechanisms involved in deposition of fat and muscular development. The research effort at Beltsville, Maryland, involves (1) the development of basic knowledge on swine physiology using animals with contrasting genetic differences, and (2) studies on reproductive physiology.

Cooperative studies at Missouri and Nebraska, which are part of the Regional Swine Breeding Laboratory program, are also included.

The Federal scientific effort on research in this area totals 1.4 scientific man-years. Of this number, 0.8 is on physiology of reproduction, and 0.6 on physiology of growth and development.

### PROGRAM OF STATE EXPERIMENT STATIONS

The total research effort on swine physiology by State agricultural experiment stations is 13.5 scientific man-years.

### PROGRESS--USDA AND COOPERATIVE PROGRAMS

#### A. Physiology of Reproduction

1. Synchronization of estrus. The data in last year's report showed that 1- $\alpha$ -methylallylthiocarbamoyl-2-methylthiocarbamoylhydrazine (ICI 33, 828) (MATCH) was effective in synchronizing the estrous cycle of gilts and sows when administered orally. The initial studies showed that this treatment had no adverse effects on ovulation rate, fertilization rate, or embryo survival. Also, the effective dosage level and duration of the feeding period were established. Primary emphasis this past year has been placed on studying



the effects of the compound on litter size. Approximately 350 sows and gilts have been treated at either Beltsville, other USDA stations, or by contract agreement with farmers. At Miles City, Montana, 127 gilts farrowed in groups of 20 to 30 within 6 weeks. About 77% came in estrus in a 24-hour span during the fifth and sixth day after the end of treatment. Over 80% of the sows conceived at first breeding. Average litter size was 9.7. At Beltsville, 32 of 36 sows returned to estrus 4 to 8 days after the end of treatment. The farrowing rate was 83%. The average litter size was 10.2. Since our first report on the use of MATCH in 1964, it has been used on all major classes of domestic livestock in 22 States. In the past year, MATCH was tested on more than 1,500 gilts and sows in the five leading hog-producing States. Preliminary reports show that conception rate and litter size were just as good as those achieved under present swine management systems. Over 75% of the animals in the studies were bred by artificial insemination. Tri-State Breeders Cooperative now offers swine artificial insemination service in Wisconsin, Iowa, Illinois, and Minnesota and will offer the synchronization treatment along with the artificial insemination service. They predict an increase in numbers of sows bred for the coming year from 1,500 to 3,000 and to 10,000 in three years. The use of this compound provides for the first time an economical and practical way for extensive use of artificial insemination of swine. (AH al-19)

Injection of follicle-stimulating hormone (FSH) induced estrus in about half of 43 sows and gilts 20 to 22 days following treatment. Ovulation rate at the first estrus after treatment and embryo survival at 25 days were not influenced by the treatment. Estrus occurred in 3 animals in less than 18 days after treatment, and 13 failed to show estrus within a 23-day period after treatment. Cystic follicles were observed in 3 animals with delayed estrus. The injection of estradiol or prolactin failed to reduce the variation in the length of time required to return to estrus after treatment. (AH al-21)

An intramuscular injection of pregnant mare serum (PMS) followed in three days by intravenous administration of human chorionic gonadotrophins (HCG) was effective in establishing experimental estrous cycles. The average interval from the injection of HCG to the first post-treatment estrus was 21.9 days. Ninety-six percent of the injected gilts and sows exhibited estrus 18 to 28 days following the injection of HCG. Animals exhibiting estrus within a 5-day period varied from 64 to 100% for 8 different groups (13 animals per group). The fertility at the first post-treatment estrus was equal to that of control animals as measured by fertilization rate, conception rate, embryo recovered, and litter size. This procedure provides an effective and dependable means of synchronizing the estrous cycle of swine with injectable gonadotrophins. (AH al-21)

Fifteen ewes and nine beef heifers were fed MATCH. Doses ranging from 0.30 to 1.25 mg./kg. of body weight were tested in ewes. Five of seven ewes at the higher dose level expressed estrus three days after the end of treatment. The data suggest that higher levels of MATCH may be required to effectively synchronize estrus in the ewe. Dose levels for the beef heifers



ranged from 0.9 to 2.0 mg./kg. of body weight. The lower levels were not effective in blocking estrus; however, all three animals at the higher dose level were effectively blocked and returned to estrus three to five days after the end of treatment. These data suggest that additional studies to test effectiveness of MATCH as a method to synchronize the estrous cycle of beef heifers and to test fertility are warranted. Effective synchronization of estrus in beef cattle can result in maximum reproductive efficiency when used in conjunction with a program of artificial insemination. (AH al-19)

## 2. Studies on embryonic mortality.

(a) Intrauterine devices. Forty-three cycling gilts were used to study the effect of a plastic coil on embryo survival in gilts. One to six plastic coils were inserted by midventral laparotomy into one or both uterine horns of the gilts; sham operated gilts served as controls. The length of the estrous cycle of the gilts was not altered. The animals were bred at the next estrous period and all returned to estrus approximately 20 days later. The gilts were then bred once again and autopsied 3 to 4, 8 to 10, or 14 days after breeding. Examination of the gilts at days 3 or 4 and 8 to 10 showed that normal ovulation, fertilization, and development of the embryos had occurred. However, by day 14 only a few atrophic embryos were found in the uterine horns of a few gilts; in the remainder no embryos were found. Average corpora lutea weight of control and treated gilts was similar at day 9. Corpora lutea weights were declining in the pregnant gilts with the plastic coil at 14 days (331 mg.) but not in the pregnant controls (448 mg.). The data show that when a spiral is present in the uterine horn it prevents the production and/or release of the luteotrophic factor from the uterus or makes the corpora lutea less receptive to the luteotrophic factor which is required in a normal pregnancy. Further studies are needed to elucidate the exact time and mechanism. (AH al-19)

(b) Embryo transplantation. Partial reciprocal embryo transfer was used to test the viability of potential young during the entire gestation period. Of 519 corpora lutea in 39 females, 433 (83.4%) ova were recovered from the oviducts 47 to 76 hours after onset of estrus. In two additional females (73 and 76 hours), the ova were recovered from the uterus. Of 70 Yorkshire and 62 Duroc embryos deposited in 15 Yorkshire females, four litters containing 15 Yorkshire and 6 Duroc pigs were farrowed. Seventeen Duroc recipients received 62 Yorkshire and 84 Duroc embryos. From this group one female had 11 embryos when slaughtered 6 days after returning to estrus (26 days after mating) and 4 farrowed 3 Yorkshire and 11 Duroc pigs. The survival of embryos in Yorkshire or Duroc uteri was not significantly different. No difference in survival between breed of embryos was observed. Twenty of the recipients were gilts (10 Yorkshire and 10 Duroc) and of 153 embryos deposited, 35 were accounted for by pigs at birth (8 gilts). One-hundred-fifteen embryos were placed in the uteri of 5 Yorkshire and 6 Duroc sows; however, none farrowed. The difference in survival between age groups was highly significant ( $P > .005$ ). One-half of the females experienced dystocia during farrowing. This



difficulty may have been due to adhesions between segments of the reproductive tract. The long return interval (av. 29.2 days) to estrus of non-pregnant recipients may be indicative of late embryonic death. (North Carolina)

(c) Location and cleavage stages of swine ova. Intrauterine migration was first observed to occur in gilts on the 11th day of pregnancy, which is prior to chorionic elongation of the blastocyst. A total of 30 gilts representing three breeds was included in the study. All gilts were laparotomized approximately 30 hours after the beginning of estrus, and at this time one Fallopian tube was occluded and 1 to 4 ml. of undiluted semen were deposited in the anterior portion of the opposite uterine horn. The gilts were slaughtered at 7 to 25 days of gestation, and the uterine horns were flushed or were opened under saline to determine the intrauterine location of the embryos. The mean ovulation rate for all gilts was 10.1. Sixty percent of the inseminated gilts were pregnant at slaughter. An average of four blastocysts or embryos were recovered, which represented 69% of the corpora lutea present on the ovary corresponding to the unoccluded horn. Intrauterine migration had not occurred in any of 7 gilts examined on days 7 to 10 of pregnancy. Migration of blastocysts to the occluded horn had occurred in 2 of 4 gilts slaughtered on the 11th day of gestation. In all gilts examined subsequent to the 11th day of pregnancy, embryos were observed in the occluded horn with the exception of one gilt representing the 13th day of pregnancy. (AH al-21)

(d) Induced corpora lutea. Ovulation was induced in nonpregnant gilts during the latter part of the luteal phase to study the effect of having corpora lutea of different ages present on the ovary. By this procedure it was possible to determine if simultaneous regression of the two groups of corpora lutea would occur without respect to age of luteal tissue. In general, when corpora lutea were induced during the luteal phase of the estrous cycle, regression of the spontaneous and induced corpora lutea was not simultaneous. Instead, the induced corpora lutea were maintained for one cycle length following formation, even though regression of the spontaneous corpora lutea occurred without any apparent change in life-span. Progesterone concentrations of the induced and spontaneous corpora lutea indicated that the functional abilities of the two sets of corpora lutea were not different prior to regression. When corpora lutea were induced in cycling gilts that were subsequently hysterectomized, both the spontaneous and induced corpora lutea were maintained for an extended period of time. The results provide evidence that the life-span of the spontaneous corpora lutea was not altered by inducing ovulation. The data provide important basic information needed to understand the role of the corpus luteum and its influence on embryo survival. (AH al-21)

3. Factors influencing estrus and fertility. Treatment with a single injection of pregnant mare serum (PMS) induced superovulation and increased fecundity in sows, but reproductive performance was not improved in cycling gilts. Ovulation rate and number of living embryos were determined in a

total of 50 gilts and sows following slaughter on approximately the 25th day of gestation. A subcutaneous injection of 1,200 I.U. of PMS was given to sows on the day the pigs were weaned and to gilts on day 17 of the estrous cycle. Only 4 of 17 treated gilts exhibited estrus within 7 days following injection of PMS. These 4 gilts were pregnant when slaughtered and had an average ovulation rate of 15 with 9.8 living embryos, as compared to an average ovulation rate of 11.8 and 8.2 embryos in 14 control gilts. Of 13 injected sows all exhibited estrus by 7 days post-treatment, 12 sows were bred, and 9 were pregnant at slaughter. Average ovulation rate and number of embryos were 23.9 and 15.8, respectively, for the treated sows as compared to an average of 11.5 corpora lutea and 9.0 embryos. (AH al-21)

An experiment was conducted with 64 second litter sows to determine if an orally active progestogen, 17-acetoxypregesterone (17-AP) and diethylstilbestrol (DES) fed to swine from day 4 to day 109 of gestation, would influence litter size, weight, and baby pig viability. A mixture of the hormones was added to the ration, approximating 2.0 mg. of 17-AP and 1 microgram of DES per kg. of body weight per day, based on the sow's weight at breeding. At farrowing no significant effects were observed on gestation gain of the sows or on the number of live and dead pigs. Pigs farrowed by treated sows were significantly heavier than controls at birth (1.28 kg. vs. 1.41 kg.,  $P>.05$ ). At 21 days the baby pigs and litters from the treated sows were significantly heavier (48.8 kg. vs. 53.6 kg. and 5.28 kg. vs. 5.71 kg., respectively,  $P>.05$ ). These differences imply that pigs from treated sows were thriftier due to improved intrauterine environment and/or the effect of the exogenous hormones on the development of the mammary gland. (AH al-8)

The influence of protein and caloric intake on reproductive performance was studied by comparing a simple corn diet (9% protein) with a corn-soybean meal diet (14% protein). Each ration was fed at two levels (4 lbs. and full-feed) from 2 to 3 weeks before breeding (3rd or 4th heat period) until slaughter at approximately 30 days of gestation. Full-feeding produced consistently more ova but tended to be detrimental to embryo survival. The 14% protein ration consistently improved ovulation rate at the 4-pound level. Some increase was also observed on the full-feeding regimen the second year. Full-feeding produced the largest litter sizes at slaughter, at 30 days, in the pregnant gilts because of the production of 3 to 6 more ova at breeding time. However, this large advantage was not maintained until slaughter because of the greater embryonic death. Also, a higher return rate was observed for the full-fed gilts. (AH al-20)

4. Effect of genetic selection on reproductive performance. Six aged Duroc boars, two from each line, selected for 10 generations on the basis of backfat thickness were used to study the effect of genetic selection on semen production. Semen was collected from the boars for 14 weeks, 2 times per week, using a dummy sow and artificial vagina. Mean total volume (ml.), strained volume (ml.), and total spermatozoa per ejaculate for the high fat,



low fat, and control lines for a 7-week period, respectively, were 200, 176,  $32 \times 10^9$ ; 172, 157,  $42 \times 10^9$ ; and 204, 187,  $52 \times 10^9$ . The boars were sacrificed at 2 years of age. Mean testis weight (gm.) for high, low, and control lines, respectively, was 275, 309, and 399. Total sperm cell production was reduced by 40% in the high-fat line and 20% in the low-fat line. This, as well as the significant reduction in testicle size, suggests that selection for a single trait has either altered hormone production or the ability of the target organ to respond to hormone output. Sperm cell production per unit of testicular tissue was similar in the control and the low-fat line but was lower in the high-fat line. It is important to note that the average carcass from the low-fat line results in 15 more pounds of lean cuts (protein) than the high-fat line at slaughter. (AH al-19)

5. The effect of protein and protein-free diets on the reproductive performance of beef bulls. Six Angus bulls, two per treatment, were fed purified rations in which dietary nitrogen was supplied by either urea, isolated soy protein, or from natural sources. The bulls were maintained on these rations from 90 days of age. Reproductive measurements were initiated at 30 weeks of age. Twelve body measurements, including weight, were taken each week. A libido score was made weekly and semen collections were made as soon as the animals would serve the artificial vagina. Percent motility and six other physical or biochemical measurements were made on ejaculates collected at weekly intervals. The criteria for puberty was the presence of  $50 \times 10^9$  sperm cells per ejaculate. Mean weights at puberty for the bulls on urea, isolated soy protein, and natural rations were 416, 477, and 569 pounds, respectively. The onset of puberty occurred, on an average, 14 weeks later in the bulls on urea than the bulls on the other treatments. Total sperm cell production at the same chronological age was  $3.2 \times 10^9$ ,  $1.4 \times 10^9$ , and  $0.5 \times 10^9$  for the natural, isolated soy, and urea bulls, respectively. Bulls on all treatments have bred and settled cows. Blood and semen samples from all bulls are being analyzed for amino acid pattern. It is of major importance to note that bulls fed urea as the only source of nitrogen maintained their capacity to reproduce. (AH al-19)

## B. Physiology of Growth and Development

1. The influence of genetic selection on physiological traits. Seventy-one market weight Duroc and Yorkshire gilts and barrows selected for either high or low backfat were used in a study to determine the effect of selection on the weight of endocrine glands, the blood cell pattern, and biochemical values of constituents in the blood serum. The animals were obtained from the 11th and 9th generations of Durocs and Yorkshires, respectively. The differences noted between the lines in the number of red blood cells, white blood cells, hemoglobin, or blood cell volume were not significant. The data show that swine which yielded a higher percent of the lean cuts also had less backfat and lower cholesterol levels. A difference has been noted between the lines in their ability to make protein in place of fat, and past generations have shown a significant difference in the weight of the anterior pituitary. (AH al-19)

2. Serum proteins. Blood samples were collected from over 900 Durocs and Yorkshires selected for high or low backfat for 10 generations. A new polyacrylamide gel electrophoresis technique was developed and used to study the transferrins (iron binding  $\beta$  globulins) and the prealbumins of pig blood serum. Over 300 animals have been typed with the newly developed system which reduces the time required per run by 12 hours. Several litters have been typed in a family study which confirms the transferrin separation. Five prealbumin bands have been separated using this system; only two have been reported in the literature previously. These data provide us with an opportunity to relate pedigree data to the polymorphisms observed in order to elucidate the type of genetic control involved and to determine whether the polymorphisms are related to any metabolic process or other economic traits of swine. (AH al-19)

3. Lactation in the sow. Milk samples were collected from 116 Duroc, Yorkshire, or crossbred sows. A polyacrylamide vertical gel slab electrophoresis system was chosen to separate the milk proteins into their component parts. A genetic polymorphism appears in the whey protein. Although it has not been specifically identified as yet, it is probably  $\beta$ -lactoglobulin. The homozygote has one band and the heterozygote has two bands, designated "A" and "B." The frequencies of the proposed alleles controlling these proteins are Yorkshire A, 33.3, B, 66.7; Duroc A, 87.5, B, 12.5; crossbred A, 80, B, 20. Family studies will have to be run to confirm this proposed polymorphism. Casein, another milk protein, has also been separated into several components by electrophoresis; however, they are very complex in sow's milk, and further fractionation and development of a system will be required to detect possible polymorphisms. At present there are no reports in the literature on the specific kinds of proteins in sow's milk. It has been known for some time that Yorkshire sows are generally better milk producers than other breeds. On the basis of this study, it is interesting to note that the frequency of the  $\beta$  gene is significantly greater in the Yorkshires than in either the Duroc or crossbred sows. (AH al-19)

4. Chemical castration of boars. Effective sterilization was induced in mature boars by a single intratesticular injection of cadmium chloride. Testicle size was reduced by 50% in 30 days. The absence of sperm cells in the ejaculates of the treated animals, as well as histological preparations, showed that sterilization is permanent. Of major importance is the fact that the Leydig cells, which are responsible for maintaining an endocrine balance which enhances deposition of protein, remain functional. This method has the potential of offering an inexpensive (5,000 treatments for \$1.00) and simple, one injection, method for castration. It is easier than surgical castration and reduces normal stresses caused by castration in both young and mature males. Further design experiments are needed to determine minimum effective dose and the effect on pigs at different ages and the influence on growth rate. (AH al-19)



PUBLICATIONS--USDA AND COOPERATIVE PROGRAMS

Physiology of Reproduction

- Day, B. N. 1965. The lifespan of corpora lutea induced during the luteal phase of the estrous cycle in swine. Proc. of Conf. on Estrous Cycle Control in Domestic Animals. USDA Misc. Publ. No. 1005. (AH al-21)
- Day, B. N. and Lasley, J. F. 1965. Alteration of the estrous cycle of swine with exogenous pituitary gonadotrophins. Mo. Agr. Expt. Sta. Res. Bul. 870. (AH al-21)
- Day, B. N., Neill, J. D., Oxenreider, S. L., Waite, A. B., and Lasley, J. F. 1965. Use of gonadotrophins to synchronize estrous cycles in swine. J. Animal Sci. 24:1075-1079. (AH al-21)
- Gerrits, R. J., Kraeling, R. R., and Sidwell, G. M. 1965. Synchronization of estrus in sheep with ICI 33,828. (Abs.) J. Animal Sci. 24:1218. (AH al-19)
- Gerrits, R. J. and Johnson, L. A. 1965. Synchronization of estrus in gilts fed two levels of ICI 33,828 and the effect on fertility, embryo survival and litter size. (Abs.) J. Animal Sci. 24:917. (AH al-19)
- Gerrits, R. J., Krehbiel, E. V., and Kincaid, C. M. 1966. Synchronization of estrus and reproductive performance of gilts fed ICI 33,828. (Abs.) J. Animal Sci. 25:923. (AH al-19)
- Longnecker, D. E., Lasley, J. F., and Day, B. N. 1965. Fecundity in gilts and sows administered PMS. (Abs.) J. Animal Sci. 24:924. (AH al-21)
- Vincent, C. K., Robison, O. W., and Ulberg, L. C. 1965. Embryo survival in swine as studied by reciprocal transfer. (Abs.) J. Animal Sci. 24:931. (North Carolina)
- Waite, A. and Day, B. N. 1965. Intra-uterine migration following unilateral fertilization in gilts. (Abs.) J. Animal Sci. 24:932. (AH al-21)
- Zimmerman, D. R. 1966. Energy and protein for the sow. Univ. of Nebr. Swine Prog. Rpt. 377:17-18. (AH al-20)

Physiology of Growth and Development

- Johnson, L. A. and Gerrits, R. J. 1965. Biochemical and hematological measurements on swine selected for high and low backfat. (Abs.) J. Animal Sci. 24:1217. (AH al-19)
- Tillson, Stephen A. 1965. Various aspects of serum cholesterol levels in swine. M.S. Thesis, Univ. of Mo. Libr., Columbia. (AH al-21)

### Related Publications of State Experiment Stations

- Day, B. N. 1965. The Lifespan of Corpora Lutea Induced During the Luteal Phase of the Estrous Cycle in Swine.  
Proc. Conf. on Estrous Cycle Control in Domestic Animals. USDA Misc. Pub. 1005 Mo.
- Day, B. N. and Lasley, J. F. 1965. Alteration of the Estrous Cycle of Swine with Exogenous Pituitary Gonadotrophins.  
Missouri Agr. Expt. Sta. Res. Bul. 870 Mo.
- Day, B. N., Neill, J. D., Oxenreider, S. L., Waite, A. B. and Lasley, J. F. 1965. The Use of Gonadotrophins to Synchronize Estrous Cycles in Swine.  
J. Anim. Sci. 24:1075 Mo.
- Dziuk, P. and Polge, C. 1965. Fertility in Gilts Following Induced Ovulation.  
Vet. Rec. 77:236 Ill.
- Gomes, W. R., Herschler, R. C. and Erb, R. E. 1965. Progesterone Levels in Ovarian Venous Effluent of the Nonpregnant Sow.  
J. Anim. Sci. 24:722-725 Ind.
- Longenecker, D. E., Lasley, J. F. and Day, B. N. 1965. Fecundity in Gilts and Sows Administered PMS.  
J. Anim. Sci. 24:924 Mo.
- Oxenreider, S. L. and Day, B. N. 1965. Transport and Cleavage of Ova in Swine.  
J. Anim. Sci. 24:413-417 Mo.
- Palmer, W. M., Teague, H. S. and Venzke, W. G. 1965. Histological Changes in the Reproductive Tract of the Sow During Lactation and Early Post-Weaning.  
J. Anim. Sci. 24:117 Ohio



Palmer, W. M., Teague, H. S. and Venzke, W. G. 1965. Macroscopic Observations on the Reproductive Tract of the Sow During Lactation and Early Postweaning.

J. Anim. Sci. 24:541

Ohio

Polge, C. and Dziuk, P. 1965. Recovery of Penetrated Immature Eggs Following Induced Ovulation in the Pig.

J. Reprod. Fertil. 9:357

Ill.

Pond, W. G., Hansel, W., Dunn, J. O., Bratton, R. W. and Foote, R. H. 1965. Estrous Cycle Synchronization and Fertility of Gilts Fed Progestational and Estrogenic Compounds.

J. Anim. Sci. 24:536-540

N.Y.

Ray, D. E. and McCarty, J. W. 1965. Effect of Temporary Fasting on Reproduction in Gilts.

J. Anim. Sci. 24:660

S.D.

Romack, F. E., Turner, C. W., Lasley, J. F. and Day, B. N. 1965. Thyroid Secretion Rate in Swine.

J. Anim. Sci. 23:1143

Mo.

Romack, F. E., Turner, C. W., Day, B. N., 1965. Anatomy of the Porcine Thyroid.

Missouri Agr. Expt. Sta. Res. Bul. 838

Mo.

Teague, H. S. and Grifo, A. P., Jr. 1965. Vitamin Intake and the Nutritive Contribution of Alfalfa to Successive Generation Performance of Swine.

J. Anim. Sci. 24:775

Ohio

Tribble, L. F., Amick, G. L., Lasley, J. F., and Zobrisky, S. E. 1965. The Effects of Stilbestrol and Sex Conditions on Growth, Carcass Characteristics and Reproductive Organs of Swine.

Missouri Agr. Expt. Sta. Res. Bul. 881

Mo.

Waite, A. and Day, B. N. 1965. Intra-Uterine Migration Following Unilateral Fertilization in Gilts.

J. Anim. Sci. 24:932

Mo.

## AREA NO. 19: SWINE--NUTRITION AND MANAGEMENT

Problem. The changing demands of the consumer for pork with a high proportion of lean are requiring major changes in the nutrition and management of swine. Furthermore, the use of materials other than lard has greatly reduced the demand for fat-type hogs. Along with the change in genetic makeup which must be made, basic facts concerning metabolic functions require investigation. Furthermore, the basic nutritional factors which influence growth and carcass composition need to be identified and evaluated. These require information on quantitative and qualitative requirements at various growth stages and the changes in requirements to adjust for altered levels of other nutrients or modified environment. To meet the competition of other foods, including other meats, the nutrition and management of swine must constantly be aimed at improvement of feed and labor efficiency. More recently the dependence on use of pesticides for protection of quality and quantity of the nation's food supply has created a difficult and sensitive problem. Although essential to maximum agricultural production, these chemicals must be used safely to prevent contamination of food or environment with harmful residues.

### USDA AND COOPERATIVE PROGRAM

This is a continuing program conducted by biochemists, nutritionists, and animal husbandmen investigating basic and applied problems in swine production related to nutrition, metabolism, and management. Work is in progress at Beltsville, Maryland, and cooperatively with the Agricultural Engineering Research Division and Entomology Research Division, as well as through informal collaborative agreements with the Food and Drug Administration, Human Nutrition Research Division, and Southern Utilization Research and Development Division. There is also a research contract with Purdue University. These studies contribute to the establishment of nutrient and mineral requirements and the relation of different components of the diet to each other; to the development of more efficient and economical rations; to the relation of genetic differences to dietary requirements; to the influence of management practices on total production, and more specifically on pesticide residues in pork products; and to the role swine may have as an experimental animal for the investigation of health and dietary problems in man.

A project entitled "Protein metabolism in monogastric animals connected with their requirements for essential limited amino acids" has been initiated at the Institute for the Application of Nuclear Energy in Agriculture, Veterinary Medicine, and Forestry, Belgrade, Zemun, Yugoslavia. It has a duration of 5 years (1966-1971) and is supported by \$94,410 equivalent in Yugoslav dinars.



The total Federal scientific effort in this area amounts to 3.3 scientific man-years. Of this number, 1.0 is devoted to digestion and metabolism; 0.2 to concentrates, evaluation, and utilization; 0.4 to feeding methods; 1.0 to nutritional requirements; and 0.7 to management practices, facilities, and equipment.

#### PROGRAM OF STATE EXPERIMENT STATIONS

The total research effort on swine nutrition and management by State agricultural experiment stations is 42.1 scientific man-years.

#### PROGRESS--USDA AND COOPERATIVE PROGRAMS

##### A. Digestion and Metabolism

The development of lines, within the Yorkshire and Duroc breeds selected for maximum and minimum backfat, made available pigs with built-in genetic differences. These have been used to measure the influence of extreme differences in type on response to nutritional variables. The first variable studied was the effect of a 25% reduction in daily gross energy intake on growth and development of pigs from these selected lines. For the period from 56 to 224 days of age (approximate market age), significant differences in rate of gain were found among the four lines as well as between full-fed and restricted energy groups within lines. Rates of gain expressed as grams per day for full-fed and restricted diets, respectively, were as follows: high-fat Yorks, 604, 493; low-fat Yorks, 639, 542; high-fat Durocs, 596, 481; and low-fat Durocs, 712, 535. The reduction in energy intake significantly improved feed efficiency (about 6%) in all lines except the low-fat Durocs which were not affected. There were marked differences in weights of lean tissue and fat from the carcasses. The weight, in kilograms, of lean tissue from carcasses of full-fed and restricted lots and fat from full-fed and restricted lots within lines is as follows: high-fat Yorks, 24.4, 25.6, 36.4, 24.0; low-fat Yorks, 31.0, 27.4, 30.0, 19.4; high-fat Durocs, 22.6, 20.0, 47.4, 33.4; and low-fat Durocs, 28.6, 26.4, 38.8, 24.8. These figures show marked differences in lean and fat content among the lines when full fed, as well as a reduction of 30 to 36% in carcass fat resulting from restricted energy intake. Energy restriction produced less consistent effects on carcass lean--being without effect on high-fat Yorks, but reducing low-fat Durocs, low-fat Yorks, and high-fat Durocs by 8%, 11%, and 12%, respectively. (AH a3-18)

##### B. Concentrates - Evaluation and Utilization

A pilot study with rats was used to measure beneficial effects from adding ferrous fumarate and lysine separately and in combination to diets formulated on either a nontoxic cottonseed meal of superior protein quality or an inferior meal which had produced toxicity in swine diets. The study

involved two trials based on the AOAC protein quality assay method. In the first trial which provided 9% of cottonseed meal protein, no benefit was obtained from either iron or lysine. In the second trial, 16% cottonseed meal protein showed substantial and additive benefits from iron and lysine as supplements to the diet containing the inferior meal, while only lysine improved the diet formulated from the good cottonseed meal with ferrous fumarate apparently producing a slightly detrimental effect. (AH a3-19)

### C. Feeding Methods

In the spring 1965 farrow (previously reported) sows which were fed essentially the same adequate level of vitamins, plus one of three different levels of feed intake daily (6.0, 4.5, or 3.0 lb.), failed to show significant differences in reproductive performance as measured by initial litter size and number or weight of pigs weaned per litter. Feeding all sows individually produced uniform intake and condition in each treatment and provided net savings of 130 and 310 pounds of feed at levels of 4.5 and 3.0 pounds, respectively. However, weaning data from the second (fall 1965) farrowing by the same sows showed marked improvement for sows receiving the 3.0 pounds level in number and weight of pigs weaned, while those on the 4.5 or 6.0 pounds daily allowances declined slightly in these criteria. The 1966 comparison repeated the 4.5 and 3.0 pounds daily allowances fed individually through gestation but omitted the 6.0 pounds allowance. Again, as in the spring of 1965, a net saving in feed consumed during gestation and lactation was recorded for the 3.0 pound level versus 4.5 pound level, but reproductive performance was not appreciably different. (AH a2-5)

The influence of feeding level on productivity and production costs was studied in 20 gilts and 20 sows. The high level females consumed an average of 7.0 pounds feed per day during gestation, compared to 4.5 pounds per day for the low level females. In this trial, sows farrowed and weaned heavier pigs and heavier litters than gilts, but differences in litter size for sows and gilts were not significant. Differences in performance between the two feeding levels were not large but tended to favor the restricted group. Both groups were self-fed during lactation. Those on limited intake during pregnancy consumed an average of 56 pounds more feed during the 6-week lactation period than those maintained at the higher level during gestation. However, for the total period from breeding to weaning, the high level group averaged 292 pounds more feed consumed per sow. Sow feed cost from breeding to weaning was almost 25% lower for those on the low level as compared to those on the high level (\$24.28 vs. \$32.31). The cost of sow feed per pig weaned was reduced approximately 34% (\$2.82 vs. \$4.25) by restricting feed intake during gestation. (AH a1-8)

### D. Nutritional Requirements - Trace Mineral Requirements and Interrelationships

1. Effects of high and low levels of calcium and zinc on excretion and retention of calcium, phosphorus, and zinc. Studies showed that barrows



ingested, excreted, and retained more calcium when fed high calcium diets than when fed the lower calcium diets. Calcium retention and excretion per unit of body weight decreased significantly. Dietary level of calcium and phosphorus had no significant effect on phosphorus utilization, but an increased calcium intake slightly reduced phosphorus retention. Age was the only factor that significantly affected intake, excretion, and retention of phosphorus. Zinc level fed had little influence. Zinc intake and excretion were significantly increased by higher levels of dietary zinc, but retention of zinc was not significantly influenced. Zinc content of livers and kidneys was increased by feeding supplemental zinc. High calcium levels in the diet decreased the zinc content of the liver. Alkaline phosphatase activity in the liver or kidney was not altered significantly by dietary treatment. Activity of the blood serum alkaline phosphatase was increased by zinc supplementation and decreased by adding calcium to the ration. The alkaline phosphatase activity of the small intestine was increased by feeding the higher level of zinc. Analysis of data on a per unit of body weight basis appeared to give the most meaningful information about the intake, excretion, and retention of the three mineral elements studied. However, any recommendations made should also include consideration of the weight of the pig since the animal's requirement per unit of body weight decreases as body weight increases. The decreased retention of calcium, phosphorus, and zinc was caused by an increased fecal excretion during the second half of each trial without a similar increase in feed intake. More investigations into changes that occur in excretory patterns when animals are closely confined in collection cages must be undertaken before too much confidence can be placed in the results of collection trials. (AH a3-12)

2. Zinc retention affected by interrelations of EDTA, calcium, and zinc. Completed analytical data from studies with weanling male rats on the effect of the chelating agent, ethylene diamine tetra acetic acid (EDTA) on zinc retention have indicated the following: (a) EDTA added at the rate of 0.1% of the diet in the presence of 1.2% calcium increased zinc retention and zinc storage in bone, hair, liver, and kidney at all zinc levels tested. This effect was not apparent when calcium content was low (0.3%). (b) The increase in zinc retention attributed to EDTA was greater at the lower levels (9 ppm or 19 ppm) of zinc than at the highest level (38 ppm). (c) Effects of EDTA were not markedly influenced by dietary levels (1.2% or 0.4%) of phosphorus. (AH a3-12)

3. Effect of dietary iron on iron content of sow's colostrum and milk. Conflicting reports concerning the capacity of certain forms of dietary iron to increase the iron content of colostrum and milk from sows fed on these compounds led to a study designed to evaluate these reports. Iron analyses were made on samples of colostrum and milk from more than 70 sows which had received various dietary treatments in three separate tests. In each test, controls were fed only conventional gestation and lactation diets without added iron supplement. Test groups received the same basal diets with iron

added at either 900 mg. or 90 mg. per pound of diet. The iron supplementation was begun about 10 days prior to farrowing and continued throughout lactation. The iron compounds added were (a) ferrous fumarate, (b) ferrous lactate, and (c) ferrous gluconate. Alfalfa was an added variable in one test. Results indicated that iron content of sow's colostrum and 35-day milk can be increased by supplementation of iron to the diet. Ferrous fumarate supplying 900 mg. iron per pound of diet was the most effective additive. Ferrous lactate at 90 mg. of iron per pound of diet was slightly more effective than 900 mg. as ferrous gluconate but less so than 900 mg. of iron from ferrous fumarate. The addition of 2 pounds of alfalfa hay to the diet appeared to increase iron content of milk and colostrum to almost the same level as adding 900 mg. of iron as ferrous gluconate. While the use of certain iron compounds as dietary supplements produced significant increases in iron content of sow's milk, it must be realized that even the increased amount of iron in the milk is still inadequate to satisfy the estimated requirements of the suckling pig for iron. (AH a3-12)

#### E. Management Practices, Facilities, and Equipment

1. Testing pesticide effect on growth and finishing. Initial investigations involving informal collaboration with the Pesticide Chemicals Research Branch of the Entomology Research Division were expanded to measure the effects of dietary exposure to heptachlor, malathion, and DDT on growing-finishing swine and on reproductive performance of female swine. In addition to feeding four levels of heptachlor (0.014 ppm to 2.8 ppm of the diet) and one level each of DDT (34 ppm) and malathion (150 ppm), one lot received heptachlor in the diet and was sprayed with malathion, and another lot was fed condemned milk produced by cows which received heptachlor-contaminated hay. The pesticides had no observable effects on health, rate of gain, or feed efficiency of pigs except for the milk-fed lot. These pigs did not gain as well as the other lots but this was attributed to known dietary inadequacies rather than pesticide content. Four representative animals were slaughtered from each treatment at the close of the growing-finishing phase, and meat cuts, livers, and lard were furnished from selected lots for evaluation by Human Nutrition Research Division. Two pigs from each pesticide treatment were shifted to the control diet, and biopsies of backfat were taken at regular intervals. Analyses of the samples taken after four months on the "clean" diet showed residue levels low enough to clear for market, except the pigs fed DDT and those fed heptachlor and sprayed with malathion. (AH a2-8)

2. Pesticide effects on reproductive performance of gilts. In the second phase on reproductive performance, six gilts from each of the lots (except the milk-fed lot) were continued on their prescribed pesticide treatments. These females have completed one gestation-lactation cycle and are approaching their second farrowing. Except for a 6-week lactation period, they have all been on their respective pesticide-containing diets for about 1 year. No adverse effects attributed to treatment have been observed



in such criteria as age at puberty, conception rate, number of pigs born or weaned, or weaning weights. (AH a2-8)

## PUBLICATIONS--USDA AND COOPERATIVE PROGRAMS

### Concentrates - Evaluation and Utilization

Cabell, C. A. and Stevenson, J. W. 1966. Studies on the effect of orally administered iron salts upon the performance of swine and rats fed gossypol. Proceedings of the Conference on Inactivation of Gossypol with Mineral Salts. New Orleans.

### Feeding Methods

Omtvedt, I. T. 1966. Reproductive performance of sows fed at two levels of intake during gestation. Okla. Expt. Sta. MP 78:14.

Robison, O. W. and Dillard, E. U. 1965. Comparison of pasture and concrete for finishing swine. ANS. Rept. No. 159, AB Series No. 4.

Robison, O. W. and Dillard, E. U. 1965. Ground mixed versus free-choice rations for finishing swine. ANS. Rept. No. 160, AB Series No. 5.

### Management Practices, Facilities, and Equipment

Earl, F. L. and Taylor, J. C. 1965. The housing and management of swine for biomedical research. Proceedings of an International Symposium at Richland, Washington, July 19-21, 1965.

#### Related Publications of State Experiment Stations

- Addis, P. B., Judge, M. D., Pickett, R. A. and Jones, H. W. 1965. Environmental factors associated with porcine adrenal size and muscle characteristics. J. Animal Sci. 24(1), pp. 127-130. Ind.
- Bunch, R. J., McCall, J. T., Speer, V. C. and Hays, V. W. 1965. Copper supplementation for weanling pigs. J. Animal Sci. 24(4), pp. 995-1000. Iowa
- Diggs, B. G., Becker, D. E., Jensen, A. H. and Norton, H. W. 1965. Energy value of various feeds for the young pig. J. Animal Sci. 24 (2), pp. 555-558. Mississippi
- Emerick, R. J., Embry, L. B. and Seerley, R. W. 1965. Rate of formation and reduction of nitrite-induced methemoglobin in vitro and in vivo as influenced by diet of sheep and age of swine. J. Animal Sci. 24 (1), pp. 221-230. South Dakota
- Eusebio, J. A., Hays, V. W., Speer, V. C. and McCall, J. T. 1965. Utilization of fat by young pigs. J. Animal Sci. 24 (4), pp. 1001-1007. Iowa
- Goode, L., Warnick, A. C. and Wallace, H. D. 1965. Effect of dietary energy levels upon reproduction and the relation of endometrial phosphatase activity to embryo survival in gilts. J. Animal Sci. 24 (4), pp. 959-963. Florida
- Greer, S. A. N., Hays, V. W., Speer, V. C., McCall, J. T. and Hammond, E. C. 1965. Effects of level of corn-and-barley-base diets on performance and body composition of swine. J. Animal Sci. 24 (4), pp. 1008-1013. Iowa
- Handling, D. L., Keese, W. C., Skelly, G. C., Wheeler, R. F. and Byrd, W. P. 1965. Effect of feed restriction on finishing swine. S. C. Agricultural Experiment Station Bulletin 521. S. Carolina



Heeney, M. W. 1965. Swine production. Colorado Agricultural Experiment Station, Bulletin 461-A. Colorado

Jensen, A. H. and Becker, D. E. 1965. Effect of pelleting diets and dietary components on the performance of young pigs. J. Animal Sci. 24 (2), pp. 392-397. Illinois

Jensen, A. H., Becker, D. E. and Harmon, B. G. 1965. Nutritional adequacy of milo for the finishing pig. J. Animal Sci. 24 (2), pp. 398-402. Illinois

Kare, M. R., Pond, W. G. and Campbell, J. 1965. Observations on taste reactions in pigs. Animal Behavior 13, pp. 265-269. N. Y.

Kornegay, E. T., Miller, E. R. and Hoefer, J. A. 1965. Urease toxicity in growing swine. J. Animal Sci. 24 (1), pp. 51-65. Michigan

Kornegay, E. T., Vander Noot, G. W., Barth, K. M., MacGrath, W. S., Welch, J. G. and Purkhiser, E. D. 1965. Nutritive value of garbage as a feed for swine. 1. Chemical composition, digestibility and nitrogen utilization of various types of garbage. J. Animal Sci. 24 (2), pp. 319-324. New Jersey

Kornegay, E. T., Miller, E. R., Ullrey, D. E. Vincent, B. H. and Hoefer, J. A. 1965. Influence of dietary urea on performance, antibody production and hematology of growing swine. J. Animal Sci. 24 (4), pp. 951-954. Michigan

Kroening, G. H., Pond, W. G. and Loosli, J. K. 1965. Dietary methionine-cystine requirement of the baby pig as affected by threonine and protein levels. J. Animal Sci. 24 (2), pp. 519-525. New York

McBee, J. L., Anderson, G. C. and Zinn, D. W. 1965. Carcass composition and growth performance of swine as affected by restricted nutrient allowance. West Virginia Agricultural Experiment Station, Bulletin 513. West Virginia

Meade, R. J., Typpo, J. T., Tumbleson, M. E., Goihl, J. H. and von der Mehden, H. 1965. Effects of protein source and level and lysine and methionine supplementation on rate and efficiency on gain of pigs weaned at an early age. J. Animal Sci. 24 (3), pp. 626-632. Minnesota

Miller, E. R., Ullrey, D. E., Zutaut, C. L., Baltzer, B. V., Schmidt, D. A., Hoefer, J. A. and Luecke, R. W. 1965. Magnesium requirement of the baby pig. J. Nutrition 85 (1), pp. 13-20. Michigan

Miller, E. R., Ullrey, D. E., Zutaut, C. L., Hoefer, J. A. and Luecke, R. W. 1965. Mineral balance studies with the baby pig: Effects of dietary magnesium level upon calcium, phosphorus and magnesium balance. J. Nutrition 86 (2), pp. 209-212. Michigan

Miller, E. R., Ullery, D. E., Zutaut, C. L., Hoefer, J. A. and Luecke, R. W. 1965. Mineral balance studies with the baby pig: Effects of dietary Vitamin D<sub>2</sub> level upon calcium, phosphorus and magnesium balance. J. Nutrition 85 (3), pp. 255-259. Michigan

Miller, E. R., Ullery, D. E., Zutaut, C. L., Hoefer, J. A. and Luecke, R. L. 1965. Comparisons of casein and soy proteins upon mineral balance and Vitamin D<sub>2</sub> requirement of the baby pig. J. Nutrition 85 (4), pp. 347-354. Michigan

Miller, E. R., Ullery, D. E., Brent, B. E., Merkel, R. A., Laidlaw, V. A. and Hoefer, J. H. 1965. Iron retention and ham discoloration: A Comparison of five injectable iron preparations. J. Am. Vet. Med. Assoc. 146 (4), pp. 331-336. Michigan

Mitchell, J. R., Jr., Becker, D. E., Jensen, A. H., Norton, H. W. and Harmon, B. G. 1965. Lysine need of swine at two stages of development. J. Animal Sci. 24 (2), pp. 409-412. Illinois

Mitchell, J. R., Jr., Becker, D. E., Jensen, A. H., Norton, H. W. and Harmon, B. G. 1965. Caloric density of the diet and the lysine need of growing swine. J. Animal Sci. 24 (4), pp. 977-980. Illinois

Nuwer, A. J., Perry, T. W., Pickett, R. A., Curtin, T. M., Featherston, W. R. and Beeson, W. M. 1965. Value of various additives to ulcer-producing gelatinized corn diets fed to swine. J. Animal Sci. 24 (1), pp. 113-119. Indiana.

Pond, W. G. 1965. Aspects of Zinc in nutrition. New York State J. Med. 65: pp. 2369-2371. New York

Pond, W. G., Barnes, R. H., Bradfield, R. B., Kwong, E. and Krook, L. 1965. Effect of dietary energy intake on protein deficiency symptoms and body composition of baby pigs fed equalized but suboptimal amounts of protein. J. Nutrition 85 (1), pp. 57-66. New York



Pond, W. G., Veum, T. L. and Lazar, V. A. 1965. Zinc and iron concentration of sow's milk. J. Animal Sci. 24 (3), pp. 668-670. New York

Ray, D. E. and McCarty, J. W. 1965. Effect of temporary fasting on reproduction in gilts. J. Animal Sci. 24 (3), pp. 660-663. South Dakota

Richardson, L. R., Hale, F. and Ritchey, S. J. 1965. Effect of fasting and level of dietary protein on free amino acids in pig plasma. J. Animal Sci. 24 (2), pp. 368-372. Texas

Rippel, R. H., Rasmussen, O. G., Jensen, A. H., Norton, H. W. and Becker, D. E. 1965. Effect of level and source of protein on reproductive performance of swine. J. Animal Sci. 24 (1), pp. 203-208. Illinois

Rippel, R. H., Harmon, B. G., Jensen, A. H., Norton, H. W. and Becker, D. E. 1965. Response of the gravid gilt to levels of protein as determined by nitrogen balance. J. Animal Sci. 24 (1), pp. 209-215. Illinois

Rippel, R. H., Harmon, B. G., Jensen, A. H., Norton, H. W. and Becker, D. E. 1965. Essential amino acid supplementation of intact proteins fed to the gravid gilt. J. Animal Sci. 24 (2), pp. 373-377. Illinois

Rippel, R. H., Harmon, B. G., Jensen, A. H., Norton, H. W. and Becker, D. E. 1965. Some amino acid requirements of the gravid gilt fed a purified diet. J. Animal Sci. (2), pp. 378-382. Ill.

Seerley, R. W. and Wahlstrom, R. C. 1965. Dehydrated alfalfa meal in rations for confined brood sows. J. Animal Sci. 24 (2), pp. 448-453. South Dakota

Seerley, R. W., Emerick, R. J., Embry, L. B. and Olson, O. E. 1965. Effect of nitrate or nitrate administered continuously in drinking water for swine and sheep. J. Animal Sci. 24 (4), pp. 1014-1019. South Dakota

Sewell, R. F. and West, J. P. 1965. Some effects of lactose on protein utilization in the baby pig. J. Animal Sci. 24 (1), pp. 239-241. Georgia

- Sewell, R. F. and Miller, I. L. 1965. Utilization of various dietary fats by baby pigs. J. Animal Sci. 24 (4), pp. 973-976. Georgia
- Sink, J. D., Watkins, J. L., Ziegler, J. H. and Kean, G. R. 1965. Radiochlorine as a tracer in fat deposition. J. Amer. Oil Chem. Soc. 42, pp. 435-437. Pennsylvania
- Smith, F. H. and Clawson, A. J. 1965. Effect of diet on accumulation of gossypol in the organs of swine. J. Nutrition 87 (3), pp. 317-321. North Carolina
- Teague, H. S. and Grifo, A. P., Jr. 1965. Vitamin intake and the nutritive contributions of alfalfa to successive generation performance of swine. J. Animal Sci. 24 (3), pp. 775-781. Ohio
- Ullrey, D. E., Miller, E. R., Struthers, R. D., Peterson, R. E., Hoefer, J. A. and Hill, H. H. 1965. Vitamin A activity of fermentation B-Carotene for swine. J. Nutrition 85 (4), pp. 375-385. Michigan
- Veum, T. L., Gallo, J. T., Pond, W. G., Van Vleck, L. D. and Loosli, J. K. 1965. Effect of ferrous fumarate in the lactation diet on sow milk iron, pig hemoglobin and weight gain. J. Animal Sci. 24 (4), pp. 1169-1173. New York.



## AREA NO. 20. FUR ANIMAL HUSBANDRY

Problem. Fur animal investigations are needed to obtain fundamental information on methods of increasing the productivity of ranch-raised fur animals. Controlled research is needed on the development of superior lines, or possibly new breeds, for producing higher quality fur. The genetics of mutations of mink and foxes and the inheritance of factors for quality of fur require continuous study. Feeding investigations are needed to determine nutritive requirement of various species and the most economical sources of feed to meet their requirements. Of special need is the finding of satisfactory substitutes for expensive raw meat. Low cost byproducts of the meat and fishing industries must be under constant study to develop practical diets. Successful husbandry of these animals requires extensive study of the peculiar characteristics of reproduction and their relation to productivity.

### USDA AND COOPERATIVE PROGRAM

This is a continuing program and involves (1) genetic investigations of traits for use in improvement of minks, martens, and foxes; (2) research on the reproductive performance of mink, including the effects of hormones and the process of lactation; (3) estimates of genetic parameters and maternal effects concerning traits; (4) studies with regard to the priming process in fur bearing animals through investigations of the mechanisms involved in the growth of hair follicles; and (5) research on the basic nutrient requirements and nutrient utilization by mink and the development of diets based on fish, meat and their byproducts for mink, fox, and marten.

The work is in progress at Beltsville, Maryland; Ithaca, New York; and Petersburg, Alaska. Cooperation is maintained with Swarthmore College and State Experiment Stations of Alaska, California, New York, and Wisconsin. Close cooperation is maintained with the National Board of Fur Farm Organizations.

The Federal scientific effort devoted to the research in this area totals 4.2 scientific man-years. Of this number 0.8 are devoted to fur animal breeding, 1.2 to fur animal physiology, and 2.2 to fur animal nutrition and management.

### PROGRAM OF STATE EXPERIMENT STATIONS

The total research effort on fur animal husbandry by State agricultural experiment stations is 4.8 scientific man-years.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Fur Animal Breeding

1. Genetics of mink with emphasis on mutant traits. The study of combinations of mutant genes affecting coat color is continuing in a herd of approximately 300 female mink in cooperation with the University of Wisconsin. Mutant genes are incorporated into the breeding herd as available. Observations on the breeding results of mink first discovered in Canada reveal that a mutant gene (J) causes a notable darkening of the pigment when introduced into individuals of the "wild type" or standard dark color. The color phase resulting when mink are of Jj or JJ genotype is called "Jet Black" by fur breeders. However, it is not known at present whether this gene is a general intensifier of melanin pigment and for this reason desirable in other mutant combinations, or whether it is able to produce black pigment per se (epistatic) and consequently useful only for this purpose. (AH f1-2)

2. Immunogenetics of the mink. The immunogenetics of the mink is under intensive study in cooperation with the University of Wisconsin. The studies revealed 4 blood type systems. Electrophoretic techniques applied to serum protein inheritance is providing information relative to the inheritance of allotypes in this species. (AH f1-2)

B. Fur Animal Physiology

1. Effect of light on reproduction in mink. Artificially increasing the length of day for mink before and during pregnancy decreased the length of gestation, and increased litter size. However, further investigation must be conducted before practical recommendation to mink ranchers can be made. Reproduction studies were carried out on 3 commercial ranches during 1966 on approximately 800 females and their progeny. (AH f2-1)

2. Effect of DDT on reproductive performance and growth in mink. During the past several years there have been clinical cases of reproduction failure in mink which may implicate Great Lakes fish. At the same time the fish have been found to contain DDT and analogs. Since in many cases these fish represent from 20 to 50% of the mink diet it was believed necessary to investigate the effects of feeding DDT upon the reproductive performance and growth of mink. In January 1966, 30 female and 15 male mink, and 20 female and 8 male rats were assigned to each of four levels of DDT, 0, 5, 10, and 100 ppm in the regular diet supplied daily. Various organs were taken monthly from similar animals so that storage and withdrawal studies could be conducted to assay the rate of buildup as well as the rate of disappearance of DDT. Results to date do not show differences among treatment groups. Another group of mink (40 female and 20 male) was added to the study later. These mink received perch scrap from fish caught in an area of Green Bay. Previous reproductive failures in mink, fed fish from this area, suggest the possibility of a relationship between poor productivity and pesticide residues, particularly DDT. This study is to be conducted



throughout three generations of mink and rats. (AH f2-6)

3. Maintenance of pregnancy in mink. The mink requires corpora lutea for maintenance of pregnancy during the last third of the period. This was confirmed in a study in which females were ovariectomized. These mink resorbed their young, while the controls gave birth in a normal manner to living kits. (AH f2-1)

4. Mating systems for marten. Marten reproduce sporadically in captivity and fail to produce young in any considerable numbers when raised in pens. During 1965 diets were varied, breeding practices changed, housing modified, and other innovations instituted at Petersburg, Alaska, in an effort to assure marten production. For the first time in 4 years, a litter of 4 kits was born at the station. (AH f1-4)

5. Evaluation of fiber population in fur animals. To obtain information on the use of biopsy skin samples as a predictive value for mink pelt quality, a histological study was done at Beltsville, Maryland, of 160 samples taken from mink at Ithaca, New York. A biopsy gun, designed at Beltsville, was used for this purpose. Forty male mink (Standard Darks and Aleutians) were biopsied on September 2, 1965. Samples from these same mink were taken again on November 17, 1965, just prior to pelting. The follicle group was used as the criterion for density. The follicle group is made up of one guard hair and the accompanying underfur fibers, which vary in number. Counts were made of the follicle group at four different levels of the skin. The results confirmed the reliability of the position of the sebaceous glands as the proper level for making these determinations. From values obtained for the individual animals for September and November, based on follicle counts, it appears that selection of mink for fiber population density can be made in early September. The animals with a range of 11 to 15 follicles per group in September showed an increase of from 8 to 13 follicles per group in November, and produced the most dense pelts. (AH f4-3)

#### C. Fur Animal Nutrition and Management

1. Development of mink diets based on sea fish and sea mammals. At Petersburg, Alaska, two iron compounds, ferrous fumarate and iron sulphate, were compared and evaluated for their ability to control anemia. Six equalized lots of 20 female mink were fed diets which included 70% fish and 5% fur seal meat. Three of these diets included vitamin E alone and in combination with ferrous fumarate and iron sulphate. The other three diets were similar except that the antioxidant BHT replaced vitamin E. After weaning, 50 kits from each lot were continued on their respective diets until December 1. While mating results were excellent, 23% of the bred females did not reproduce, and average litter size was below normal. The blood picture of mink kits receiving BHT indicated a higher average hemoglobin. Both vitamin E and BHT controlled steatitis. (AH f3-1)

2. Evaluation of beta-carotene as a source of vitamin A activity for growing mink. Knowledge of the efficiency of utilization of carotene as a source of vitamin A for mink will determine the value in the diet of vegetable products as a source of vitamin A. Sixty kit mink were started at 3 weeks of age on purified diets deficient in vitamin A and fed these diets until approximately 13 weeks of age. Tests on similar animals showed livers to be depleted of vitamin A at 13 weeks of age. At this time the mink were divided into 6 groups and given oral supplementation for 11 weeks, adjusted weekly according to their weight. Gains were 780 gms for the groups receiving the vitamin A, 512 gms for the groups receiving carotene, and 142 gms for the controls. Vitamin A supplementation resulted in liver storage at the level of 400 I.U. of vitamin A, whereas carotene supplementation resulted in little vitamin A in either blood or liver. Beta-carotene is not efficiently used by mink as a source of vitamin A activity. It is of some value but should not be considered as a source of vitamin A in practical feeding. (AH f3-5)

3. Development of dry diets for mink. In order to determine if the drying process was destroying some nutrient or nutrients or decreasing the palatability, 10 pairs of brothers were placed on each of the two following diets. One of each pair of brothers received a regular mink diet of meat, fish, liver, cottage cheese, cooked eggs, and a dry mix. The other brother of each pair received the same diet which had been freeze-dried at 30°C for 48 hours at an atmospheric pressure of from 100-200 mm. of mercury, and then reconstituted and fed in a manner similar to the regular diet. The mink were started on these diets on July 1 at approximately 8 weeks of age and the study was terminated on November 3 when the mink were pelted. Growth and feed efficiency figures were better for the group receiving the dried and reconstituted diet. The final weight of the controls was 2127 gms (gain 1433) and the final weight of those receiving the reconstituted dried diet was 2225 gms (gain 1531). This demonstrates that for growth a typical diet, dried under laboratory conditions, will support as good or better growth than the same diet fed under ranch conditions. (AH f3-5)

4. Vitamin B<sub>6</sub> requirements of growing mink. In order to formulate a satisfactory diet for the growing mink, it is necessary that the requirements of various nutritional factors be known. No information is available regarding the B<sub>6</sub> requirement of this species.

Five male and five female weanling mink per group were assigned to semi-purified diets containing the following levels of vitamin B<sub>6</sub>: (0.0), (0.75), (1.5), (3.0), and (6.0) mg/kg of diet. The study was terminated after 11 weeks. At this time all mink of the control group had lost weight or died, whereas the mink receiving supplemental vitamin B<sub>6</sub> had gained an average of at least 600 gms. Three mink transferred from the deficient diet to the diet containing B<sub>6</sub> at a level of 6.0 mg/kg rapidly gained weight. Two males receiving 0.75 mg/kg B<sub>6</sub> supplementation appeared quite irritable and a third showed a convulsion. These preliminary results indicate that the



vitamin B<sub>6</sub> requirement of young mink is probably between 0.75 and 1.5 mg/kg of diet. Pilot studies presently being conducted indicate that the vitamin B<sub>6</sub> deficient mink exhibits a sharply elevated xanthurenic acid excretion following a tryptaphan load and shows some promise in evaluating the B<sub>6</sub> status of the mink. These studies are being continued during 1966 with emphasis on the effects of B<sub>6</sub> deficiency on metabolism. (AH f3-5)

#### PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

##### Fur Animal Breeding

Rapacz, Jan and Shackelford, R.M. 1966. Erythrocyte antigen mosaicism in domestic mink. J. Hered. 57(1): 19-22. (AH f1-2)

Shackelford, Richard M. 1966. Types of mink - Section 1. The Blue Book of Fur Farming. (AH f1-2)

Shackelford, Richard M. 1966. A mutation to black reported in mink. The Blue Book of Fur Farming. (AH f1-2)

Shackelford, Richard M. and Hartsough, G. R. 1966. Breeding - Section IV. The Blue Book of Fur Farming. (AH f1-2)

##### Fur Animal Physiology

Rust, Charles C., Shackelford, R.M. and Meyer, R. K. 1965. Hormonal control of pelage cycles in the mink. J. Mammalogy 46(4): 549-565. (AH f2-1)

##### Fur Animal Nutrition and Management

Travis, H. F., Bassett, C. F., Warner, R. G. and Reineke, E. P. 1966. Some effects of feeding products high in naturally occurring thyroactive compounds upon reproduction of mink (Mustela vison). Am. J. Vet. Res. May, 815-817. (AH f3-6)

Travis, H. F. and Bennett, L. W. 1965. Effects of artificially increased length of day upon the reproductive performance of mink. U. S. Fur Rancher, November, pp. 6, 8, 25. (AH f2-1)

### Related Publications of State Experiment Stations

Adair, J., F. M. Stout and J. E. Oldfield. Comparisons of mink ration formulas. Ore. Agr. Exp. Stat. Spec. Rpt. 185. 1965. 36 pp. Oregon

Amann, R. P., H. H. Koefoed-Johnsen, H. Levi. 1965. Excretion pattern of labelled spermatozoa and the timing of spermatozoa formation and epididymal transit in rabbits injected with thymidine-3H. J. Reprod. Fertil., 10:169-183. Penna.

Aulerich, R. J., L. Holcomb, R. K. Ringer and P. J. Schaible. 1965. Influence of lighting on mink reproduction. Fur Breeder, Feb., p. 10. Michigan

Aulerich, R. J., and P. J. Schaible. 1965. Use of a tranquilizer for hard-to-breed female mink. Mich. Agr. Exp. Sta. Quart. Bul. 47(2):220-224. Michigan

Aulerich, R. J. and P. J. Schaible. 1965. The use of "spent" chickens for mink feeding. Mich. Agr. Exp. Sta. Quart. Bul. 47(3):451-458. Michigan

Aulerich, R. J. and P. J. Schaible. 1965. A preliminary report on "spent" chickens for mink feeding during reproduction and early kit growth. Mich. Agr. Exp. Sta. Quart. Bul. 48(1):13-16. Michigan.

Aulerich, R. J. and P. J. Schaible. 1965. A semi-dry diet for mink during reproduction, lactation and early kit growth. Mich. Agr. Exp. Sta. Quart. Bul. 48(1):17-22. Michigan

Oldfield, J. E., F. M. Stout and J. Adair. Advances in mink ration formulation. National Fur News. 37:12-13. 1965. Ore.



## AREA NO. 21: ANIMAL PERFORMANCE AND MANAGEMENT RECORDS

Problem. Effective livestock and poultry improvement cannot be accomplished effectively without adequate records of performance and management. In order to have widespread utility, these records must be produced through carefully coordinated programs yielding uniformity in measurements, standardized analytical procedures, and accuracy and integrity in animal identification and genealogy. Continual revision of uniform data collection, reporting and evaluation techniques in accordance with current research findings requires integration of program operations and research. Only in this manner can there be a continual chain of discovery, field testing, and application with the needed genetic and environmental improvement.

### USDA AND COOPERATIVE PROGRAM

This is a continuing long-term program of performance testing dairy cattle and poultry, including the evaluation of the genetic merit of dairy cows, sires and herds, chickens for egg or meat production, and turkeys. Also included in the program is the control of egg-transmitted poultry diseases. The work on dairy cattle performance testing is cooperative with 50 States and Puerto Rico and the Records and Breeding Committees of the American Dairy Science Association. Cooperation is also carried out with the National Association of Animal Breeders and the various dairy cattle breed registry organizations. The poultry work is cooperative with Official State Agencies in 47 States and with the supervisors of 23 random sample tests in the United States and Canada.

A dairy recordkeeping contract with Computer Usage Development Corporation provided \$32,070 during the year for conversion of data processing programs.

The Federal scientific effort devoted to the programs in this area totals 4.1 scientific man-years. Of this number, 2.1 are devoted to dairy cattle performance testing and 2.0 to poultry performance testing.

### PROGRESS -- USDA AND COOPERATIVE PROGRAMS

#### A. Dairy Cattle

1. Sire evaluation program. A total of 1,760,503 records of performance reported during the year, along with the 11 1/2 million records available in magnetic tape files, were used in producing 17,725 individual genetic appraisals of sires. From these, the dairy industry and cooperators were provided with 53,848 sire records. These genetic appraisals were made on a quarterly basis and included all sires qualifying with five or more progeny having herdmates. A total of 1,281,958 progeny were included in the genetic appraisals. The dairy industry was also provided a publication including the latest summary of the 28,845 individual bulls evaluated between August 1963 and November 1965. (AH i4-1)

2. Cow evaluation program. Genetic appraisals were made of the registered cows in DHIA and the resulting indexes of performance made available to the industry on a semiannual basis. A total of 580,000 cows were indexed biometrically and the top 2% identified. This indexing procedure provides the industry with a reliable and uniformly derived estimate of breeding value. These sire and cow evaluations are especially adaptable to genetic improvement through artificial insemination. (AH i4-1)

3. Dairy recordkeeping programs. The 1,418 dairy herd improvement associations, employing 2,378 supervisors, provide the organizational structure for visiting farms and for reporting data in the 50 cooperating States. The percentage of the nation's cows enrolled in the National Cooperative Dairy Herd Improvement Program was 19.1%, an increase of 0.7% over the previous year. The actual number of herds and cows enrolled declined slightly and was as follows:

<u>Plans</u>	<u>Herds</u>	<u>Cows</u>
Standard DHIA	38,879	2,058,592
Owner-Sampler	26,259	839,838
Weigh-a-Day-a-Month	1,160	56,957
Total	66,298	2,955,387

The artificial breeding program, through which the superior sires developed and recognized in DHIA herds are utilized, bred a total of 7,264,835 dairy and 615,147 beef cows. This represents 43.7% of the Nation's dairy cows of breeding age. An average of 3,402 cows per sire was inseminated during the year. The total of 7,879,982 dairy cows was inseminated by 2,316 bulls. (AH i4-2)

4. DHIA record analysis and research.

(a) Recordkeeping statistics. Cows in Standard DHIA herds produced 12,127 pounds of milk and 462 pounds of milk-fat per cow-year in 1965-66. This was 4,668 pounds of milk more than from cows not enrolled in the Standard DHIA. The superiority of Standard DHIA cows has remained practically constant for the past 3 years.

Cows in DHIA continue to be fed higher levels of feed. They provided an estimated income over feed cost of \$303 per cow. This return compares with an estimated income over feed cost of \$295 in 1964-65; \$284 in 1963-64; \$279 in 1962-63; and \$295 in 1961-62. (AH i4-3)

(b) Evaluation of procedures for estimating age correction factors. Further studies were made of methods of estimating the regression of lactation yield on age at calving. Two commonly used methods, the paired and gross comparisons, were compared to a more complicated maximum-likelihood procedure that is theoretically more accurate. The results were according to theory,



in that the maximum-likelihood age factors were most accurate. The gross comparison factors were slightly less accurate and the paired comparison factors were the least reliable. Results indicated that the more easily derived gross comparison factors are slightly biased, but are generally satisfactory in adjusting production records for age effects. (AH i4-3)

(c) Environmental influences on age correction factors. A study of a large sample of DHIA lactation records from all areas of the United States showed that age correction factors vary significantly between milk and fat yield and among seasons, regions, and breeds. The magnitude of these differences among traits, regions, seasons, and breeds was such that the use of factors stratified by all these variables is necessary to avoid biases in genetic evaluations of cows and sires. (AH i4-3)

(d) DHIA age adjustment factors. Sets of multiplicative factors were developed for use in further standardizing DHIA lactation records for age at calving. It was necessary to develop 22 sets of factors stratified by breed, region, season of calving (summer and winter), age at calving, and milk and milk fat. These factors will significantly increase the usefulness of all DHIA records of performance, and will especially reduce the likelihood of inconsistencies in genetic appraisals of cows and sires. (AH i4-3)

(e) Environmental influences on ratios of part-to-total yield. Analyses were conducted on ratios computed from 52,412 DHIA lactations obtained from the Iowa Dairy Records Processing Center. Ratios were significantly affected by breed, age, season, and milk and milk fat. Age was the most important influence within a breed, but stratification by two age groups, less than 3 years and greater than 3 years of age, accounted for most of the variation. It was concluded that ratios used to project incomplete lactations to a 305-day basis should be stratified by breed, age, milk and milk fat, and season when operationally feasible. (AH i4-3)

(f) Relationship between initial and later AI sire progeny groups. The progeny of 471 Holstein bulls used extensively in AI were analyzed to determine accuracy of initial sire summaries. The results showed that the increase in accuracy obtained with additional progeny is lower on a nationwide basis than suggested by earlier studies based on data from only one region. Generally, initial summaries of AI bulls sampled in many herds were more reliable in predicting the performance of future daughters than those from bulls sampled in few herds. Results suggested that the number and distribution of herds represented in an initial sire evaluation should be taken into account when appraising AI sires, and that further research on regional influences on sire evaluations should be undertaken. (AH i4-3)

(g) Relationships between sire summaries at different herd levels. DHIA progeny of 40 Holstein bulls, each having 1,000 daughters or more,

were stratified into four groups based on level of herdmates and analyzed. Progeny averages were highly related to level of herdmate production, indicating that efforts to rank AI bulls on their daughter performance without regard to the production of their herdmates can be very misleading. Both product moment and rank correlations indicated that sire progeny groups will rank in about the same order, regardless of the herd production level at which they are evaluated. It was concluded that the Predicted Difference measure, now used as the final evaluation of AI bulls in DHIA, at least partially accounts for differences in herdmate production level. (AH i4-3)

(h) Evaluation of age effects for different stages of lactation. Environmental influences on age factors for partial lactations were studied using data for 36,463 lactations of DHIA Holstein cows in Iowa. Age curves were found to differ markedly with stage of lactation. The effects of age also varied among seasons and between milk and fat production. (AH i4-3)

(i) Evaluation of different methods of estimating breeding values of bulls in artificial insemination. A study was initiated to evaluate the usefulness of maximum-likelihood estimation in the measurement of breeding values of AI sires. This method was compared to least squares and herdmate comparison procedures. Preliminary results indicate that the practical utility of maximum-likelihood procedures may be limited. (AH i4-3)

(j) Choosing population averages for use in sire evaluation. DHIA breed-state-year-season lactation averages were studied to determine the relative importance of several sources of variation and to develop more accurate procedures for adjusting for variation in number of herdmates in genetic appraisals. Analyses indicated that, within a breed, state to state variation was the most important factor. Year and season were also significant effects. It was concluded that the use of a breed-region-year-season average in lieu of the previously used nationwide breed-season average will increase the accuracy of sire and cow evaluations significantly. (AH i4-3)

(k) Research on herd averages. DHIA averages for the years 1960-64 for 4,337 herds were studied to ascertain the relationship between feed, cost, income, and production data. Amount of concentrate fed appeared to be the major factor affecting production changes both within and between herds. Considerable differences in the efficiency of concentrate usage by cows were evident between regions, as the regressions of milk on concentrate varied from 0.65 to 1.15 lbs. milk/lb. concentrate. (AH i4-3)

(l) Estimates of parameters from a nationwide AI population. Sources of variation were evaluated from 618,923 AI progeny lactations of 432 Holstein bulls. An analysis of variance showed that herds accounted for 28% of the variation in lactation records, and 11 regions and its interactions accounted for 5%. Years, seasons, and months were jointly



associated with 5% of the variance, and sires 3.6%. Expressing lactation records for milk yield as deviations from herdmates removed only 77%, 78%, and 85% of the regional, monthly, and seasonal variation, respectively; but was 99% effective in removing year differences. Only 17% of the region-year-season interaction variance was deleted. Results indicated that the regional variation remaining in records expressed as deviations from herdmates may be of sufficient magnitude to cause inconsistencies in sires evaluated only in one or several regions. (AH i4-3)

## B. Poultry

1. National Poultry and Turkey Improvement Plans. Over 12.8 thousand flocks containing 34.2 million breeding chickens and 1.5 thousand turkey flocks containing 3.9 million birds were officially classified under National Plan standards. All flocks qualified for a disease control classification and 96.0% of the chickens and 97.2% of the turkeys were also classified under one of the breeding phases of the Plans. These birds produced hatching eggs for 1,311 chicken hatcheries with incubator capacity of 328 million eggs, and 290 turkey hatcheries with capacity for 49.4 million eggs.

More than 14.7 thousand prospective breeding flocks containing 38.3 million birds were tested for pullorum disease and fowl typhoid. The number of reactors to the initial blood test for pullorum-typhoid in chickens reached an all-time low of .001% of the birds tested. For the first time in the history of the National Turkey Improvement Plan, no pullorum-typhoid reactors were found in the flocks tested. Approximately 85% of the turkey flocks tested for pullorum-typhoid were also tested for S. typhimurium and M. gallisepticum. Of the birds tested, .016% reacted to the S. typhimurium test and .141% reacted to the M. gallisepticum test. More than 78.4% of the flocks participating in the National Turkey Improvement Plan met the requirements for the typhimurium control program and more than 85.7% were qualified for the U. S. M. Gallisepticum Tested classification.

Cooperating diagnostic laboratories reported 142 isolations of pullorum and typhoid organisms. Approximately 2/3 of these cases were followed up with field investigations by cooperating State Agencies. It is expected that increasing numbers of these infections will be traced to their sources and eliminated as potential disseminators of the two diseases. The cooperating laboratories report the diagnosis of paratyphoid as well as pullorum and typhoid. During recent years, the reports show a steady decline in pullorum-typhoid, while the incidence of paratyphoid has increased rapidly. In 1965, laboratories reported 1,467 cases of paratyphoid as compared to 396 in 1960. The laboratory reports also indicate a rapid increase in the incidence of paracolon infection in turkeys.

The 1966 National Plans Conference recommended changes in the provisions of the Plans which should improve the effectiveness of the disease control program. The recommended changes provided for a Mycoplasma gallisepticum control program in the National Poultry Improvement Plan similar to that now

in operation under the National Turkey Improvement Plan. The recommended changes in the National Turkey Improvement Plan included provisions for the recognition of States from which pullorum-typhoid appears to have been eliminated. This should contribute to more rapid progress toward the eradication of these infections.

The trend toward greater use of cross-mating in chick production continued during 1965-66. More than 77% of all chickens in participating flocks were cross-mated. Conversely, less than 2% of the turkey breeding flocks were cross-mated. The growing acceptability of the large white turkey is reflected in the 1965-66 participation reports which show that for the first time more than one-half of the birds in participating flocks were of this variety. (AH e5)

2. Random sample performance tests. Data from 16 United States and 4 Canadian random sample egg laying tests were submitted to the Poultry Improvement office in 1965. The 1964 and 1965 data were combined into a two-year summary. This combination of data over the two-year period permitted comparison of the performance of 117,601 laying hens in 1,649 pens, and 122 different stocks tested at 65 locations in the United States and Canada. The combining of data obtained over a two-year period permitted more reliable predictions of the performance of stocks than the use of a single year's data. The results of these computations, expressed as regressed means, are predictions of what the performance of a stock would be, had it been tested at all 65 locations over the two-year period. These regressed means, along with the statistical significance of differences, expressed as 80% confidence limits, were computed for 16 economic traits of each stock tested.

The supervisors of three Random Sample Turkey Tests submitted records on 3,000 individual turkeys, representing 30 entries of 18 different stocks that were tested in 52 pens. These data were analyzed separately by tests, and Duncan's Multiple Range Test was applied to 12 traits to show the statistical significance of difference between entries within a test. (AH e5)

#### PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

##### Dairy Cattle

Conlin, B. J. and Cole, C. C. 1966. Estimates of parameters from a nationwide artificial insemination population. J. Dairy Sci., 49:748. (Abs.) (AH i4-3)

McDaniel, B. T. and Corley, E. L. 1966. Environmental influences on age correction factors. J. Dairy Sci., 49:736. (Abs.) (AH i4-3)

McDaniel, B. T., Miller, R. H., and Corley, E. L. 1966. Relationships between initial and later AI sire progeny groups. J. Dairy Sci., 49:724. (Abs.) (AH i4-3)



- McDaniel, B. T., Miller, R. H., and Corley, E. L. 1965. Choosing population averages for use in sire evaluation. J. Dairy Sci., 48:1559. (Abs.) (AH i4-3)
- McDaniel, B. T., Miller, R. H., and Corley, E. L. 1965. DHIA factors for projecting incomplete records to 305 days. Dairy Herd Improvement Letter. August 1965. ARS 44-164. (AH i4-3)
- Miller, R. H., Harvey, W. R., Tabler, K. A., McDaniel, B. T., and Corley, E.L. 1966. Maximum likelihood estimates of age effects. J. Dairy Sci., 49:65-73. (AH i4-3)
- Dairy Herd Improvement Letters. ARS 44-162, 166, 171; 1965. ARS 44-173, 175, 177, 178, 181; 1966.
- DHIA Sire Summary List. Aug. 1965. ARS 44-165, 267 pp.; Nov. 1965. ARS 44-168, 201 pp.; Aug. 1963-Nov. 1965. ARS 44-172, 334 pp.; Feb. 1966. ARS 44-174, 364 pp.; May 1966. ARS 44-179, 127 pp.
- DHIA Cow Performance Index List. Aug. and Nov. 1965. ARS 44-170, 275 pp.; Feb. and May 1966. ARS 44-180, 216 pp.

### Poultry

- Breed Distribution of NPIP Participating Flocks. Percentage Distribution, by Varieties, for All States Reporting (For Years Ending June 30, 1950-1965). ARS 44-2.
- Tables on Hatchery and Flock Participation in the National Poultry Improvement Plan by States and Divisions, 1963-64 and 1964-65 and U. S. Summary 1959-60 to date. ARS 44-3.
- Tables on Hatchery and Flock Participation in the National Turkey Improvement Plan by States and Divisions, 1963-64 and 1964-65 and U. S. Summary 1959-60 to date. ARS 44-4.
- Hatcheries and Dealers Participating in the National Poultry Improvement Plan. ARS 44-6.
- Annual ROP and Performance Test Summary, 1964-1965. ARS 44-7.
- Participants in the National Turkey Improvement Plan. ARS 44-8.
- Turkeys in NTIP Flocks and Their Distribution by States and Varieties, 1953-54, 1963-64 and 1964-65. ARS 44-11.
- Turkey Performance Tests. 1965. ARS 44-13.
- 1965 Report of Egg Production Tests, United States and Canada. ARS 44-79-6.

NPIP and NTIP Official State Agencies. CA-44-7.

Producers of Bantams, Ducks, Geese, and Game Birds. CA-44-25.

Poultry Stocks Available for Export by Breeders or their Agents in the United States. CA-44-51.

Related Publications of State Experiment Stations

Poultry Performance and Management Records

Andrews, L. D., Hobbs, T. D. and Lankford, L. T. 1965. Arkansas Random Sample Commercial Egg and Controlled Environment Test No. 2. Rept. Series 136, Ark. Agr. Exp. Sta. Arkansas

Andrews, L. D. and Lankford, L. T. 1965. Arkansas Meat Performance Egg Phase and Reproduction Test No. 9. Rept. Series 146, Ark. Agr. Exp. Sta. Arkansas

Marble, D. R. 1965. Changes in the Pattern of Egg Production. Poul. Sci. 44(2), pp. 601-608 New York

Simco, Joseph S. and Lancaster, J. L., Jr. 1965. Control of Common External Parasites on Commercial Layers and Hatchery Flocks. Bul. 703, Ark. Agr. Exp. Sta. Arkansas



## AREA NO. 22: PRODUCTION INFLUENCES ON ANIMAL PRODUCTS

Problem. Beef, lamb, pork, and poultry are excellent sources of wholesome and digestible animal proteins and fatty acids necessary in maintaining a healthy, appetizing diet. However, these meats must be of high quality, as well as in plentiful supply, if they are to retain their high position and esteem in the minds of consumers. Proper finish, a high proportion of lean, with adequate intramuscular fat, tenderness, full flavor, and color desired by the consumer are the goals the meat producer must strive to attain through breeding, feeding, and management. The quality of cuts and kind of meat are directly reflected in the demand and in the price of the product.

Egg shell strength and yolk quality, strength of wool, fatness, quantity, flavor, color, and tenderness of meat are all known to be influenced by production practices. However, these quality characteristics and many more are not well understood, even though they are of considerable economic importance. Effective measures of evaluating quality differences are of great importance in determining the nature and effect of production practices on the products.

### USDA AND COOPERATIVE PROGRAM

This is a continuing program conducted by food product technologists, wool and fiber technologists, biochemists, chemists, physiologists, statisticians, and animal husbandmen engaged in both basic and applied research designed to develop methods and information which will be useful in evaluating quality and quantity of animal products and will be useful in aiding and directing livestock production. Research on beef, veal, lamb, and pork is directed at the influence of selection and breeding, nutrition, physiology, management, and other production variables on carcass and meat quality and quantity. Standards are being applied and adapted for appraisal of slaughter animals, of carcasses, and of meat cuts. The objective of the work with poultry and eggs is to ascertain those factors of nutrition, breeding, and management which contribute to the initial quality of poultry products and their capacity to retain that quality. Studies with wool, fur, and fiber are conducted to determine the physical, chemical, and biological structures and properties of wool and other animal fibers as influenced by production factors. The work is conducted at Beltsville, Maryland; Dubois, Idaho; Fort Wingate, New Mexico; Glendale, Arizona; and in cooperation with four State experiment stations. Cooperation is also carried out with the Eastern and Western Utilization Research and Development Divisions, the Human Nutrition Research Division, the Agricultural Engineering Research Division, and the Market Quality Research Division.

The Federal scientific effort devoted to research in this area totals 5.7 scientific man-years. Of this total 1.6 are devoted to beef; 1.0 to lamb, mutton, and chevon; 1.0 to pork; 0.8 to poultry and eggs; and 1.3 to wool, fur, and fiber.

A grant with the Polish Academy of Sciences in Poland, which provided for studies on the color of pork as influenced by heredity, sex, age, feeding, and management, has been completed.

#### PROGRAM OF STATE EXPERIMENT STATIONS

The total research effort on production influences on animal products by State agricultural experiment stations is 28.0 scientific man-years.

#### PROGRESS -- USDA AND COOPERATIVE PROGRAMS

##### A. Beef

1. Growth and maturity. Studies on growth and maturity in beef steers from 6 months to 7 years are underway. During the first 6 months of growth, one-half of the animals were fed ad lib on a well balanced fattening ration. The other half were restricted to a per day weight gain of 0.75 to 1.25 pounds on the same ration. The ad lib fed animals slaughtered at 6 months of age were heavier; had a higher dressing yield; a much heavier liver; individual muscles were approximately one-third heavier; and had slightly lower yield of lean and bone, and a slightly higher yield of fat. The ad lib fed steers had longer, deeper, and wider carcasses, and longer individual muscles that had larger cross-section areas.

The steers representing 12 months of growth have been slaughtered. One group was fed ad lib the entire 12 months. A second group was fed a restricted ration. A third group was fed a restricted ration the first 6 months, then ad lib the second 6-month period. The results indicate that the group of steers fed ad lib dressed higher, had heavier individual muscle and bone weights, higher yield of separable fat, and less lean than those on the restricted ration. The animals in the third group were intermediate in these respects. The meat samples from the ad lib animals were significantly more tender and palatable than those of the second or third group. When these data are compared to those from 6-month old animals, it is interesting to note that tenderness and overall desirability of meat from ad lib steers improved. On the other hand, meat from both groups of steers that were restricted in feed for 6 or 12 months remained the same in tenderness, but improved some in palatability. (AH d4-7)

2. Tenderness evaluation techniques. A study of some of the physical responses of muscle fibers of selected beef muscles indicated that the pre-rigor contraction of Sternun mandibularus, in response to exposure to 0°C. (cold shortening), often resulted in "localized" contraction and a passive contraction of adjacent muscle fibers. Frequently the sarcomere lengths of contracted fibers were about 1.0 micron, while adjacent uncontracted fibers measured 2.3 microns.



The tensile strength of cold shortened Sternun mandibularus muscle was not significantly different from control samples held at ambient temperatures. Tensile strength of raw tissue increased from about 6 kilograms per square centimeter at 1 or 2 hours postmortem to about 10 Kg/cm<sup>2</sup> at 5 or 6 hours. By 48 hours the tensile strength plateaued to 3 or 4 Kg/cm<sup>2</sup> and maintained this through 7 days postmortem. The tensile strength of tissue cooked to 55° or 70° for 90 seconds was not significantly different from that of raw tissue.

Longissimus dorsi muscle fibers had lower tensile strength, often reaching the low level of 1 Kg/cm<sup>2</sup> within 5 days postmortem. The Infraspinatus muscle of beef, although quite high in collagen content, possessed tensile strengths and STE values similar to those of Longissimus dorsi. This work was conducted at the Low Temperature Laboratory, Cambridge, England.  
(AH d4-6)

## B. Lamb, Mutton, and Chevon

1. Preslaughter treatment. A study was completed to evaluate qualitatively the possible changes in amino acids or ninhydrin reactive substances in the plasma of sheep subjected to different preslaughter treatments. Preslaughter treatment consisted of immobilization by captive bolt or electric shock. The relative concentrations of isoleucine decreased and the concentration of valine increased with electric shock. Plasma amino acid nitrogen was not significantly changed. The total concentration of amino acids increased when electric shock was used.  
(AH b6-1)

2. Factors affecting carcass traits and rate of gain in fed lambs. The effects of ration (wheat, corn, milo and barley), sex (one testicle rams, intact rams, wethers, and short-scrotum lambs), and line of breeding were investigated in cooperation with the New Mexico Agricultural Experiment Station. This was studied in relation to rate and efficiency of gain and to carcass characteristics of lambs. Feed efficiency was highest in the one testicle and intact rams and lowest in the wether lambs.

Lambs fed the corn ration weighed more at slaughter and scored higher for dressing and grade. Lambs fed the barley ration weighed less at slaughter and scored lowest for dressing and grade. Lambs on the corn ration showed the highest daily gains, while those on the wheat ration showed the lowest daily gains. Carcasses from the one testicle rams graded the highest. Wether lambs had the highest dressing percentage but were the slowest gaining lambs. (AH b1-10, 11, 12)

3. Fat content of lamb carcasses. A wide range in fat content was found in carcasses from lambs killed at a weight of approximately 100 pounds at Beltsville, Md. The carcass samples included bone, one kidney, and one-half of the total kidney fat. The mean ether extract was 27.4%. The range was 16.0 to 40.3%. (AH b6-1)

4. Relationship between lamb growth and carcass composition. The carcasses from wether lambs were studied at the Oklahoma Agricultural Experiment Station. One-half of the lambs were sired by blackfaced rams and one-half by whitefaced rams. One-half of the lambs by each sire were born and raised as singles and one-half as twins. The lambs were slaughtered at a weight of 100 pounds. The blackfaced-ram-sired-lambs grew faster after weaning and produced carcasses with more lean and bone than lambs from the whitefaced rams. Lambs that were heaviest at birth had less fat and more lean and bone in the carcass when slaughtered. Percent fat and amount of lean in the carcass was best estimated by wholesale cut fat trim, loin fat trim, or specific gravity of the hind saddle. Percent bone was best predicted by weight of the cannon bones. (AH b3-7)

#### C. Pork

1. Carcass evaluation. Continued statistical analyses were made on the data from 56 Poland China pigs, divided into two groups according to degree of finish and/or type, and slaughtered at age increments of 5 weeks. The analyses showed a significant variation between rates of development of musculature at different ages. Significant variation was found in rates of growth between muscles. No significant variation was found when small type musculature was compared to large type musculature. Types of muscles varied in their development at specific ages. (AH a4-3)

2. Color. Research on color in pork as influenced by heredity, sex, age, feeding, and management, as a PL 480 project with Poland, was completed. The results of the study showed significant differences in color of lean between gilts and barrows, the former being darker. Dominant wave length and saturation of color increased with age. Lightness did not change, but its stability increased. A high energy ration produced significantly paler meat with less pigment than a low energy ration. An increasing level of digestible protein in the ration improved the color of lean tissue. Kind of feed had no influence on color. Higher gains and shorter fattening periods lowered saturation of meat color. Pigs with thinner backfat had lower color scores. Forcing pigs to obtain feed from a raised shelf increased saturation of color and protein content. Significant variations were found in lightness, saturation and stability of meat color, water-holding capacity, intramuscular fat content and myoglobin content, thus suggesting a heredity consideration. (E 21-AH-2)

#### D. Poultry and Eggs

Research on egg quality includes cooperative work with the agricultural engineers at Beltsville. A method has been developed to measure the strength of egg shells. This method involves the dropping of a 1/4-inch diameter steel ball from progressively higher heights until the shell is broken. This technique was developed to check the accuracy of a beta energy backscatter technique developed in cooperation with the Atomic



Energy Commission. This method consists of firing small beta particles at the egg, and measuring how many beta particles bounce back to a Geiger-Mueller tube around the beta emitter. Most of the beta particles bounce back from a rugged shell; whereas, there is little reflectance from a fragile shell. It takes about 15 seconds to tell the difference. Research is in progress to further reduce this analyzing time.

E. Wool and Fiber

1. Factors affecting quality and value of wool. Studies on the relationship between quality traits and economic factors affecting the value of graded lines of grease wool were continued.

These results show that in wool of 64/70's quality, length and clean content were more important quality factors than degree of fineness. In the coarser wools, 60/62's through 46/48's, the clean fiber content was a more important factor than either length or fineness. (AH b5-2)

2. Measuring methods to evaluate wool. At Beltsville, Maryland, additional data have been accumulated and are in process of analysis to shorten the time involved in measuring crimp in grease wool. The method reported previously has been accepted as a tentative standard by the American Society for Testing and Materials.

Comparisons of average diameter and variability have been made on 8 samples of wool top, using the short fiber method and-EFFI, Electronic Fiber Fineness Indicator. A preliminary study of the results indicates that the diameters are the same by both methods but that the variability is greater with EFFI. More detailed studies of the results are being made.

Studies are being continued on the use of the air flow method for determining average fineness of wool and mohair. Interlaboratory tests are being conducted to determine the usefulness of three samples of top of known diameter as standard samples to be used to calibrate instruments on an interlaboratory basis. Preliminary results indicate that the wools from which these samples were taken can be so used.

The rotary-type cutting instrument has been completed for use with the Coulter Counter to determine fineness and variability of wool top. Tests on known samples, using the short fiber method and the Coulter Counter, indicate that the cutting instrument is usable and is giving reliable results. (AH b5-3c)

3. Relation of fleece traits to processing characteristics. Studies were continued on the relationship among quality traits, yield, and quality of top on 14 breed-grade lots of mature Rambouillet, Targhee, and Columbia ewe wool from Dubois, Idaho. The wools were scoured at the University of Wyoming and processed into top at the Philadelphia College of Textiles

and Science. Comparisons were made using data accumulated over the past 6 years with special attention to the relationship of data on Rambouillet and Targhee wools which were visually classed as the same grade. These preliminary analyses indicated that the Rambouillet wool was significantly shorter, finer, and more crimped than Targhee wool of the same visual grade. The differences in top yield, noil yield, and percent of fibers shorter than 2 inches in the top were not significantly different between the 2 breeds. (AH b5-7)

#### PUBLICATIONS -- USDA AND COOPERATIVE RESEARCH

##### Beef

Alsmeyer, R. H., J. W. Thornton, R. L. Hiner and N. C. Bollinger. 1966. Beef and Pork Tenderness Measured by the Press, Warner-Bratzler, and STE Methods. Food Technology, 20(5) 115-117. (AH d4-6)

##### Lamb

Whiteman, Joe V., Walters, Lowell E., and Munson, A. W. 1966. Some relationships between lamb growth and carcass composition and among various measures of carcass merit. Oklahoma Agricultural Experiment Station, 40th Annual Livestock Feeders' Day Report, Misc. Public. 78, pp. 40-49. (AH b3-7)

##### Pork

Janicki, M. A., S. Kilaczyk and J. Kortz. 1966. Color of Meat as Influenced by Level of Nutrition in Pigs. Roczniki Nauk Rolniczych Tom 88-B-1 -- 1966. Presented at the 9th Conference of Meat Research Institute, Budapest, 1963. (E-21-AH-2)

Janicki, M. A., J. Kortz and J. Rozyczka. 1966. Relationships Between Color and Other Physical and Chemical Properties in Fresh Pork Meat. Presented at the 12th Conference of Meat Research Institute, 1966. (E-21-AH-2)

##### Poultry and Eggs

McNally, E. H. 1965. Variation of percentages and ratios of parts to the whole as illustrated by components of the egg. Poultry Sci. 44:1398.

##### Wool and Fiber

Houriham, Mary, Chairman, Task Group, D-13. Tentative Method of Test for Staple Crimp in Grease Wool Locks. ASTM Designation: D2491-T, 1966. (AH b5-3c)



## Related Publications of State Experiment Stations

### A. Production Influences on Beef, Pork, and Lamb.

Addis, P. B., et al. 1965. Environmental factors associated with porcine adrenal size and muscle characteristics. J. Animal Sci. 24(1), pp. 127-130. Indiana

Beecher, G. R., et al. 1965. Red and white fiber content and associated post-mortem properties of seven porcine muscles. J. Food Sci. 30(6), pp. 969-976. Wisconsin

Beecher, G. R., Briskey, E. J., and Hoekstra, W. G. 1965. A comparison of glycolysis and associated changes in light and dark portions of the porcine semitendinosus. J. Food Sci. 30(3), pp. 477-486. Wisconsin

Birkett, R. J., Good, D. L., and Mackintosh, D. C. 1965. Relationship of various linear measurements and percent yield of trimmed cuts of beef carcasses. J. Anim. Sci. 24(1), pp. 16-20. Kansas

Bodwell, C. E., Pearson, A. M., and Spooner, Mildred E. 1965. Post-mortem changes in muscle. I. Chemical changes in beef. J. Food Sci. 30(5), pp. 766-772. Michigan

Bodwell, C. E., Pearson, A. M., and Fennell, R. A. 1965. Post-mortem changes in muscle. III. Histochemical observations in beef and pork. J. Food Sci. 30(6), pp. 944-954. Michigan

Borchert, L. L. and Briskey, E. J. 1965. Protein solubility and associated properties of porcine muscle as influenced by partial freezing with liquid nitrogen. J. Food Sci. 30(1), pp. 138-143. Wisconsin

Burnside, H. H., et al. 1965. Effect of cooking on intramuscular lipids of beef muscles. Fed. Proc. Am. Soc. Exp. Biol. 24(2), p. 496. Louisiana

- Cabezas, M. T., et al. 1965. Effect of diet on fatty acid composition of body fat in steers. J. Anim. Sci. 24(1), pp. 57-61. Florida
- Carpenter, J. A., and Saffle, R. L. 1965. Some physical and chemical factors affecting the emulsifying capacity of meat protein extracts. Food Technol. 19(10), pp. 111-115. Georgia
- Carpenter, Z. L., et al. 1965. Interrelationships of muscle color and other pork quality traits. Food Technol. 19(9), pp. 115-117 (Coop. with USDA). Wisconsin
- Carpenter, Z. L., et al. 1965. Objective and subjective measures of pork quality. Food Technol. 19(9), pp. 118-120. Wisconsin
- Carpenter, Z. L., and King, G. T. 1965. Tenderness of lamb rib chops. Food Technol. 19(11), pp. 102-104. Texas
- Chacko, G. K. and Perkins, E. G. 1965. Anatomical variation in fatty acid composition and triglyceride distribution in animal depot fats. J. Am. Oil Chem. Soc. 42(12), pp. 1121-1124. Ill.
- Christiansen, Lee. N. and Foster, E. M. 1965. Effect of vacuum packaging on growth of Clostridium botulinum and Staphylococcus aureus in cured meats. Appl. Microbiol. 13(6), pp. 1023-1025. Wisconsin
- Cook, C. F., Bray, R. W., and Weckel, K. G. 1965. Variations in the chemical and physical properties of three bovine lipid depots. J. Anim. Sci. 24(4), pp. 1192-1194. Wisconsin
- Cromwell, G. L., et al. 1965. Effect of frequency of feeding on performance and carcass characteristics of swine. Ind. Agr. Exp. Sta. Res. Progr. Rpt. 202, 5 p. Indiana
- Dinkel, C. A., et al. 1965. Ratios and percents as measures of carcass traits. J. Anim. Sci. 24(2), pp. 425-429. Sou. Dakota
- Eisenhut, R. C., et al. 1965. Fiber arrangement and microstructure of bovine longissimus dorsi muscle. J. Food. Sci. 30(6), pp. 955-959. Wisconsin
- El-Gharbawi, Mohamed I. and Dugan, L. R., Jr. 1965. Stability of nitrogenous compounds and lipids during storage of freeze-dried raw beef. J. Food Sci. 30(5), pp. 817-822. Michigan



El-Gharbawi, Mohamed I. and Dugan, L. R., Jr. 1965. Steam-volatile components from freeze-dried beef stored at room temperature. J. Food Sci. 30(5), pp. 814-816. Michigan

Fitzhugh, H. A., Jr., et al. 1965. Methods of predicting the weight of boneless roast and steak meat from easily obtained beef carcass measurements. J. Anim. Sci. 24(1), pp. 168-172. Texas

Forrest, J. C., et al. 1965. Porcine muscle properties. B. Relation to naturally occurring and artificially induced variation in heart and respiration rates. J. Food Sci. 30(3), pp. 492-497. Wisconsin

Galal, E., et al. 1965. Relationships among weights and linear measurements in sheep and heritability estimates of some of these measurements. J. Anim. Sci. 24(2), pp. 388-391. Texas

Giam, I. and Dugan, L. R., Jr. 1965. The fatty acid composition of free and bound lipids in freeze-dried meats. J. Food Sci. 30(2), pp. 262-265. Michigan

Gifford, J. 1965. Tenderness and flavor of lamb leg steaks. Wash. Agr. Exp. Sta. Bull. 660, 13 p. Washington

Gillett, T. A., Pearson, A. M., and Kirton, A. H. 1965. Variation in potassium and sodium in muscles of the pig. J. Anim. Sci. 24(1), pp. 177-181. Michigan

Goll, D. E., et al. 1965. Effect of marbling and maturity on beef muscle characteristics. II. Physical, chemical, and sensory evaluation of steaks. Food Technol. 19(5), pp. 163-167. Iowa

Gould, Paul F., Bratzler, L. J., and Magee, W. T. 1965. Effect of aging on tenderness of pork loin chops. Food Technol. 19(2), p. 146. Michigan

Greer, S. A. N., et al. 1965. Effects of level of corn- and barley-base diets on performance and body composition of swine. J. Anim. Sci. 24(4), pp. 1008-1013. Iowa

Guenther, J. J., et al. 1965. Growth and development of the major carcass tissues in beef calves from weaning to slaughter weight, with reference to the effect of plane of nutrition. J. Anim. Sci. 24(4), pp. 1184-1191. Oklahoma

- Haas, Martin C. and Bratzler, L. J. 1965. Determination of myoglobin oxygenation rates in pork, beef and lamb by Munsell and reflectance colorimetry. J. Food Sci. 30(1), pp. 64-68. Mich.
- Handlin, D. L., et al. 1965. The effect of feed restriction on finishing swine. S. C. Agr. Exp. Sta. Bull. 521. Sou. Carolina
- Hedrick, H. B., et al. 1965. Influence of ante-mortem stress on meat palatability. J. Anim. Sci. 24(1), pp. 255-263. Missouri
- Hedrick, H. B., et al. 1965. Factors affecting longissimus dorsi area and fat thickness of beef and relation between these measurements and retail yield. J. Anim. Sci. 24(2), pp. 333-337. Mo.
- Henrickson, R. L., Pope, L. S., and Hendrickson, R. F. 1965. Effect of rate of gain of fattening beef calves on carcass composition. J. Anim. Sci. 24(2), pp. 507-513. Oklahoma
- Herring, H. K., Cassens, R. G., and Briskey, E. J. 1965. Further studies on bovine muscle tenderness as influenced by carcass position, sarcomere length, and fiber diameter. J. Food Sci. 30(6), pp. 1049-1054. Wisconsin
- Herring, H. K., Cassens, R. G., and Briskey, E. J. 1965. Sarcomere length of free and restrained bovine muscles at low temperatures as related to tenderness. J. Sci. Food and Agr. 16, pp. 379-384. Wisconsin
- Huston, C. K., et al. 1965. Fatty acid composition changes in meat lipids during low temperature storage. J. Am. Oil Chem. Soc. 42(2), pp. 141-145. Penna.
- Jacobs, J. A., Kemp, J. D., and Moody, W. G. 1965. The effects of pancreatic lipase and papain on quick-aged, dry-cured hams. Ky. Anim. Sci. Res. Rpt. 45. Kentucky
- Jacobs, J. A. Kemp, J. D., and Moody, W. G. 1965. The effects of muscle quality on quick-aged, dry-cured hams. Ky. Anim. Sci. Res. Rpt. 43. Kentucky
- Johnston, W. K., Jr., et al. 1965. Effects of coumestrol and diethylstilbestrol on the organoleptic quality of lamb. J. Anim. Sci. 24(3), pp. 718-721. Oregon



Kastenschmidt, L. L., et al. 1965. Porcine muscle properties. A. Alteration of glycolysis by artificially induced changes in ambient temperature. J. Food Sci. 30(4), pp. 565-572. Wisc.

Klosterman, E. W., Althouse, P. G., and Cahill, V. R. 1965. Effect of corn silage or ground ear corn full fed at various stages of growth and fattening upon carcass composition of beef cattle. J. Anim. Sci. 24(2), pp. 454-458. Ohio

Knight, A. D. and Foote, W. C. 1965. Influence of breed-type, feed level and sex on lamb carcass characteristics. J. Anim. Sci. 24(2), pp. 786-789. Utah

Kuchmak, M. and Dugan, L. R., Jr. 1965. Composition and positional distribution of fatty acids in phospholipids isolated from pork muscle tissues. J. Am. Oil Chem. Soc. 42(1), pp. 45-48. Mich.

Law, Helen M., et al. 1965. Consumer acceptance studies. I. Frozen prefabricated beef cuts. La. Agr. Exp. Sta. Bull. 596, 18 p. Louisiana

Law, Helen, M., et al. 1965. Consumer acceptance studies. II. Ground beef of varying fat composition. La. Agr. Exp. Sta. Bull. 597, 20 p. Louisiana

Luckett, R. L., Kemp, J. D., and Moody, W. G. 1965. Partial pumping of hams. Ky. Anim. Sci. Res. Rpt., 47. Kentucky

Lynch, G. P., Thornton, J. W., Hiner, R. L., Travis, H. F., and Wellington, G. H. 1965. Variation in the sodium and potassium levels of lambs subjected to preslaughter carbon dioxide immobilization. J. Anim. Sci. 24(1), pp. 235-238 (Coop. with USDA). N. Y.

Martin, T. G. and Judge, M. D. 1965. Prediction of lean content of lamb carcasses. Ind. Agr. Exp. Sta. Res. Progr. Rep. 194, 3 p. Indiana

Martin, T. G. and Starkenburg, R. T. 1965. Genetic correlations between beef and dairy traits in dual-purpose cattle. World Rev. Anim. Prod. 1:45-52. W. Virginia

McBee, J. L., Anderson, G. C., and Zinn, D. W. 1965. Carcass composition and growth performance of swine as affected by restricted nutrient allowance. W. Va. Agr. Exp. Sta. Bull. 513, 17 p. W. Virginia

- McClain, P. E., et al. 1965. Relationship of alkali insoluble collagen to tenderness of three bovine muscles. J. Anim. Sci. 24(4), pp. 1107-1110. Louisiana
- McClain, P. E., et al. 1965. Acid and salt-soluble collagen in bovine muscle. Proc. Soc. Exp. Biol. and Med. 119, pp. 492- La.
- McIntosh, Elaine Nelson. 1965. Isolation of mucoprotein in bovine skeletal muscle. J. Food Sci. 30(6), pp. 986-990. Iowa
- McLaren, G. A., Anderson, G. C., and Barth, K. M. 1965. Influence of methionine and tryptophan on nitrogen utilization of lambs fed high levels of non-protein nitrogen. J. Anim. Sci. 24(1), pp. 231-234. W. Virginia
- McLaren, G. A., Anderson, G. C., and Barth, K. M. 1965. Influence of folic acid, vitamin B<sub>12</sub> and creatine on nitrogen utilization of lambs fed levels of non-protein nitrogen. J. Anim. Sci. 24(2), pp. 329-332. W. Virginia
- Miller, Eunice M. and Harrison, Dorothy L. 1965. Effect of marination in sodium hexametaphosphate solution on the palatability of loin steaks. Food Technol. 19(1), pp. 94-97. Kansas
- Miller, J. C., et al. 1965. Factors affecting longissimus dorsi and subcutaneous fat measurements and indices of beef carcass cut-out. Mo. Agr. Exp. Sta. Res. Bull. 880, 44 p. Missouri
- Miller, W. A. 1965. Bacterial counts of prepackaged frozen and unfrozen pork and veal cutlets--breaded and unbreaded. J. Milk and Food Technol. 28(7), pp. 217-219. Kansas
- Moody, W. G., Zobrisky, S. E., Ross, C. V., and Naumann, H. D. 1965. Ultrasonic estimates of fat thickness and longissimus dorsi area in lambs. J. Anim. Sci. 24(2), pp. 364-367. Missouri
- Naumann, H. D. 1965. Evaluation and measurement of meat quality. In Food Quality, ed. by G. W. Irving, Jr. and S. R. Hoover, pp. 239-249. Missouri
- Paul, Pauline C. 1965. Storage - and Heat-induced changes in the microscopic appearance of rabbit muscle. J. Food Sci. 30(6), pp. 960-968. California



- Pearson, A. M. 1965. The influence of nutrition and management upon meat quality. In Food Quality, ed. by G. W. Irving, Jr. and S. R. Hoover, pp. 267-286. Michigan
- Perklev, T., et al. 1965. Excretion of radioactivity by human subjects after ingestion of liver from cattle treated with labeled polydiethylstilbestrol phosphate. Proc. Soc. Exper. Biol. and Med. 119, p. 996. Colorado
- Rampton, J. H., Anglemier, A. F., and Montgomery, M. W. 1965. Fractionation of bovine sarcoplasmic proteins by DEAE-cellulose chromatography. J. Food Sci. 30(4), pp. 636-640. Oregon
- Ritchey, S. J., and Hostetler, Robert L. 1965. The effect of small temperature changes on two beef muscles as determined by panel scores and shear-force values. Food Technol. 19(8), pp. 93-95. Texas
- Ritchey, S. J. 1965. The relationships of total, bound, and free water and fat content to subjective scores for eating quality in two beef muscles. J. Food Sci. 30(2), pp. 375-381. Virginia
- Rogers, Robert W., Kemp, James D., and Varney, W. Y. 1965. Effects of enzyme addition on palatability, tenderness, and rancidity development in quick-aged country-style hams. Food Technol. 19(10), pp. 134-137. Kentucky
- Romans, J. R., Tuma, H. J., and Tucker, W. L. 1965. Influence of carcass maturity and marbling on the physical and chemical characteristics of beef. I. Palatability, fiber diameter and proximate analysis. J. Anim. Sci. 24(3), pp. 681-685. S. Dak.
- Romans, J. R., Tuma, H. J., and Tucker, W. L. 1965. Influence of carcass maturity and marbling on the physical and chemical characteristics of beef. II. Muscle pigments and color. J. Anim. Sci. 24(3), pp. 686-690. S. Dakota
- Sanderson, A., Bodwell, C. E., and Pearson, A. M. 1965. Thin-layer chromatography of sugar phosphates from muscle. Nature 206, p. 938. Michigan
- Sharrah, Nancy, Kunze, Marion Simone, and Pangborn, Rose Marie. 1965. Beef tenderness: sensory and mechanical evaluation of animals of different breeds. Food Technol. 19(2), pp. 131-136. California

- Sharrah, Nancy, Junze, Marion Simone, and Pangborn, Rose Marie. 1965. Beef tenderness: comparison of sensory methods with the Warner-Bratzler and L. E. E.-Kramer Shear Presses. Food Technol. 19(2), pp. 136-143. California
- Sink, J. D., et al. 1965. Radiochlorine as a tracer in fat deposition. J. Am. Oil Chem. Soc. 42(5), pp. 435-437. Penna.
- Sink, J. D., et al. 1965. Rigor mortis pattern of skeletal muscle and sarcomere length of the myofibril. Biochem. Biophys. Acta 102, pp. 309-311. Wisconsin
- Skelley, George C., Jr. and Ackerman, Carl W. 1965. Pork processing and curing. S. C. Agr. Exp. Sta. Bull. 77 (Rev.), 16 p. (Coop. with Usda). South Carolina
- Smith, F. H. 1965. Determination of free and bound gossypol in swine tissues. J. Am. Oil Chem. Soc. 42(2), pp. 145-147. N. Car.
- Snyder, H. 1965. Analysis of pigments at the surface of fresh beef with reflectance spectrophotometry. J. Food Sci. 30(3), pp. 457-463. Iowa
- Spurlock, G. M., and Bradford, G. E. 1965. Comparison of systems of lamb carcass evaluation. J. Anim. Sci. 24(4), pp. 1086-1091. California
- Swanson, L. A., Kline, E. A., and Goll, D. E. 1965. Variability of muscle fiber size in bovine longissimus dorsi. J. Anim. Sci. 24(1), pp. 97-101. Iowa
- Topel, D. G., Merkel, R. A., and Mackintosh, D. L. 1965. Relationships between certain whole muscles and measures of pork carcass muscling. J. Anim. Sci. 24(2), pp. 514-518. Kansas
- Tribble, L. F., et al. 1965. The effects of stilbestrol and sex conditions on growth, carcass characteristics and reproductive organs of swine. Mo. Agr. Exp. Sta. Res. Bull. 881, 20 p. Mo.
- Urban, W. E. and Hazel, L. N. 1965. Ultrasonic measurement of fattening rate in swine. J. Anim. Sci. 24(3), pp. 830-833 (Coop. with USDA). Iowa
- Walter, M. J., et al. 1965. Effect of marbling and maturity of beef muscle characteristics. I. Objective measurements of tenderness and chemical properties. Food Technol. 19(5), pp. 159-163. Iowa



- Walters, Lowell and Martin, Everett. 1965. The association of beef carcass conformation with thick and thin meat yields. Okla. Agr. Exp. Sta. Misc. Publ. 76, p. 5. Oklahoma
- Williams, L. D. and Pearson, A. M. 1965. Unsaponifiable fraction of pork fat as related to boar odor. J. Agr. and Food Chem. 13(6), pp. 573-577. Michigan
- Wise, M. B., et al. 1965. Influence of rumen buffering agents and hay on performance and carcass characteristics of steers fed all concentrate rations. J. Anim. Sci. 24(1), pp. 83-88. N. Car.
- Wismer-Pedersen, J. 1965. Effect of EDTA and pH on properties of freeze-dried pork muscle. I. Effect of pH and magnesium and calcium ions on freeze-dried myofibrils. J. Food Sci. 30(1), pp. 85-90. Michigan
- Wismer-Pedersen, J. 1965. Effect of EDTA and pH on properties of freeze-dried pork muscle. II. Effect of injection of EDTA and NaOH before drying. J. Food Sci. 30(1), pp. 91-97. Michigan
- Yoshikawa, K., et al. 1965. 1-pyrroline: The odor component of Strecker-degraded proline and ornithine. J. Food Sci. 30(6), pp. 991-994. Oregon

#### B. Production Influences on Poultry Products

- Aulerich, Richard J. and Schaible, Philip J. 1965. The use of "spent" chickens for mink feeding. Quarterly Bulletin Mich. Agr. Exp. Sta. 47 (3), pp. 451-458. Michigan
- Beane, W. L., Siegel, P. B. and Siegel, H. S. 1965. Piperazine compounds and yolk discoloration. Poul. Sci. 44 (3), pp. 666-668. Virginia
- Bigland, C. H., Bennett, Esther and Abbott, Ursula K. 1965. The effect of pyrrole-2-aldehyde chalcone derivatives on the incidence of blood spots in chicken eggs. Poul. Sci. 44 (1), pp. 140-144. California
- Chung, R. A., Rogler, J. C. and Stadelman, W. J. 1965. The effect of dietary cholesterol and different dietary fats on cholesterol content and lipid composition of egg yolk and various body tissues. Poul. Sci. 44 (1), pp. 221-228. Indiana

- Essary, E. O. and Dawson, L. E. 1965. Quality of fryer carcasses as related to protein and fat levels in the diet. 1. Fat deposition and moisture pick-up during chilling. Poul. Sci. 44 (1), pp. 7-15. Virginia
- Evans, Robert John, Bandemer, Selma L. and Davidson, J. A. 1965. Failure of epoxy and hydroxy fatty acids to cause egg discoloration when fed to laying hens. Poul. Sci. 44 (4), pp. 1097-1099. Michigan
- Fry, Jack L., Moore, J. S. and O'Steen, A. W. 1965. Strain difference and initial quality relationships to rate of interior egg quality decline. Poul. Sci. 44 (3), pp. 649-652. Florida
- Fry, Jack L., Wallegghen, Paul van, Waldroup, P. W. and Harms, R. H. 1965. Fish meal studies. 2. Effects of levels and sources on "fishy flavor" in broiler meat. Poul. Sci. 44 (4), pp. 1016-1019. Florida
- Heywang, B. W., Heidebrecht, A. A. and Kemmerer, A. R. 1965. Discolorations in stored eggs when layers at two locations were fed cottonseed meals made from glandless and glanded seed. Poul. Sci. 44 (2), pp. 573-577. Arizona
- Marion, J. E. 1965. Effect of age and dietary fat on the lipids of chicken muscle. J. Nutrition 85 (1), p. 38. Georgia
- Marion, J. E., Woodroof, J. G. and Cook, R. E. 1965. Some physical and chemical properties of eggs from hens of five different stocks. Poul. Sci. 44 (2), pp. 529-534. Georgia
- May, K. N., and Noles, R. K. 1965. Effect of hesperidin and litter moisture on growth and carcass defects of broilers. Poul. Sci. 44 (3), pp. 844-848. Georgia
- Meredith, W. E., Weiser, H. H. and Winter, A. R. 1965. Chlor-tetracycline and oxytetracycline residues in poultry tissues and eggs. Appl. Microbiol. 13 (1), p. 86. Ohio
- Moreng, R. E., Jones, M. L., Whittet, W. A., Hartung, D. L. and McPherron, T. A. 1965. A fresh mixed feed system for poultry and other livestock. Popular Bulletin 525-S, Colorado Agricultural Experiment Station. Colorado
- Richards, J. F. and Swanson, M. H. 1965. The relationship of egg shape to shell strength. Poul. Sci. 44 (6), pp. 1555-1558. Minn.



Richardson, L. R., Cannon, Martha L. and Webb, B. D. 1965. Relation of dietary protein and lysine to free amino acids in chick tissues. Poul. Sci. 44 (1), pp. 248-257. Texas

Sadler, W. W. and Corstvet, R. E. 1965. The effect of experimental Mycoplasma synoviae on the wholesomeness of young market-age chickens. Am. J. Vet. Res. 26 (115), p. 1413. California

Sauter, E. A., Petersen, C. F., Lampman, C. E. and Wiese, A. C. 1965. A study of the influence of dehydrated alfalfa meal on the production of blood spots in eggs. Poul. Sci. 44 (1), pp 52-62. Idaho.

Silvestrini, D. A., Dawson, L. E. and Evans, R. J. 1965. Effects of nicarbazin in diet on mottled yolks. 2. Lipids. Poul. Sci. 44 (5), pp. 1285-1291. Michigan

Silvestrini, D. A., Dawson, L. E., Evans, R. J. and Davidson, J. A. 1965. Effects of nicarbazin in diet on mottled yolks. I. Incidence and degree of mottling, and certain yolk proteins. Poul. Sci. 44 (2), pp. 467-473. Michigan

Stadelman, W. J., Liska, B. J., Langlois, B. E., Mostert, B. C. and Stemp, A. R. 1965. Persistence of chlorinated hydrocarbon insecticide residues in chicken tissues and eggs. Poul. Sci. 44 (2), pp. 435-437. Indiana

Taylor, M. Hal, Fry, Jack L. and Smith, Lewis T. 1965. Factors affecting quality and tenderness in turkey steaks. Poul. Sci. 44 (3), pp. 669-673. Kansas

Line Project Check List -- Reporting Year July 1, 1965 to June 30, 1966

Work & Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Project Leader or Leaders	Line Proj. Incl. In	
				Summary of Progress	Area & Subheading
AH a1 AH a1-8	Swine Breeding Investigations Selection for combining ability of three lines of swine	Stillwater & Ft. Reno, Okla.	J. A. Whatley, Jr., & C. E. Shelby	Yes	17-A, 17-B-2 18-A-3 19-C
AH a1-9	Inbreeding, linecrossing, and selection within and between the Hampshire, Duroc and Yorkshire breeds of swine	Brookings, Eureka, & Centerville, S. Dak.	J. W. McCarty & C. E. Shelby	Yes	17-B-3
AH a1-10	Methods of breeding and selection in swine	Madison, Wisc.	A. B. Chapman & C. E. Shelby	Yes	17-A 17-B-2 17-C
AH a1-11	Recurrent reciprocal selection for high specific combining ability in crosses between Yorkshire and Montana No. 1 swine	Miles City, Mont.	C. M. Kincaid, H. O. Hetzer & E. V. Krehbiel	Yes	17-B-2
AH-a1-12	Selection for high and low degrees of fatness in swine	Beltsville, Md.	C. M. Kincaid & H. O. Hetzer	Yes	17-A 17-B-1
AH a1-13	Reciprocal recurrent selection for general and specific combining ability in two strains of swine	Beltsville, Md.	C. M. Kincaid & H. O. Hetzer	Yes	17-A 17-B-2
AH a1-16	Effectiveness of selection in purebred and crossbred founda- tion stocks	Urbana, Ill.	H. W. Norton & C. E. Shelby	No	
AH a1-17	Selection, inbreeding and crossing for swine improvement	Duluth, Waseca, Morris, Crookston, Grand Rapids & Rosemount, Minn.	R. E. Comstock W. E. Rempel & C. E. Shelby	Yes	17-B-4,6
AH a1-18	A comparison of selection proced- ures within lines of swine used for crossbreeding	Lafayette & Farmland, Ind.	V. A. Garwood & C. E. Shelby	No	
AH a1-19	Exploration of metabolic pathways that interrelate biochemical and genetic differences in swine populations	Beltsville, Md.	C. M. Kincaid	Yes	18-A-1,2, 4,5 18-B-1,2, 3,4
AH a1-20	The nature of genetic variability in gene pools of swine	Lincoln, North Platte & Scotts Bluff, Nebr.	L. J. Sumption & C. E. Shelby	Yes	17-A 17-B-5 18-A-3
AH a1-21	Effects of selection for low back- fat thickness on various performance traits and carcass desirability in swine	Columbia, Mo.	J. F. Lasley & C. E. Shelby	Yes	17-A 18-A-1,2, 3
AH a1-22	Genetic relationships between purebred and crossbred swine	Ames & Ankeny, Ia.	L. N. Hazel & C. E. Shelby	Yes	17-A 17-B-4 17-C
AH a1-23	Selection for maximum genetic improvement in swine with a minimum of expenditures	East Lansing, Mich.	W. T. Magee & C. E. Shelby	No	
AH a2 AH a2-3	Swine Management Investigations Evaluation of new or improved type of hog-rearing equipment	Beltsville, Md.	C. M. Kincaid & J. W. Stevenson	No	
AH a2-5	The evaluation of management practices as they affect swine production	Beltsville, Md.	C. M. Kincaid & J. W. Stevenson	Yes	19-C
AH a2-6(C)	Control of flies and other insects associated with swine production without the use of insecticides	Lafayette, Ind.	C. M. Kincaid	No	



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Work & Line Project Number	Work and Line Project Titles *	Work Locations During Past Year	Project Leader or Leaders	Line Proj. Incl. In	
				Summary of Progress	Area & Subheading
AH a2-8	Residue content in body tissues and consequences to swine from exposure to pesticides*	Beltsville, Md.	D. P. Morgan J. W. Stevenson & C. M. Kincaid	Yes	19-E-1,2
AH a3	Swine Feeding and Nutrition Investigations				
AH a3-12	Trace mineral requirements and biochemical pathways relating to mineral utilization by swine	Beltsville, Md.	I. P. Earle & J. W. Stevenson	Yes	19-D-1,2,3
AH a3-18	Nutrient metabolism and deposition of specific body tissues by pigs with genetic differences in performance, type, and breed	Beltsville, Md.	R. J. Davey, J. W. Stevenson & C. M. Kincaid	Yes	19-A
AH a3-19	To evaluate the nutritive quality and safety of improved cotton-seed meals and reexamine methods for improving the safety in feeding of cotton seed meals produced under current commercial processes	Beltsville, Md.	J. W. Stevenson, I. P. Earle & C. A. Cabell	Yes	19-B
AH a4	Pork Studies				
AH a4-3	Meat characteristics of carcasses of pork developed through breeding, nutrition and management	Beltsville, Md.	R. L. Hiner	Yes	22-C-1,2

\*Initiated during reporting year

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Work & Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Project Leader or Leaders	Line Proj.	Incl.in
				Summary of Progress	Area & Subheading
AH b1	Sheep breeding investigations				
AH b1-1	Selecting mating and breed comparisons of sheep for farming regions	Beltsville, Md.	G.M.Sidwell & C.E.Terrill	Yes	14-B-1
AH b1-2	Lamb and wool production from crosses among several breeds of sheep	Beltsville, Md.	G.M.Sidwell & C.E.Terrill	Yes	14-B-1
AH b1-3	Development of a strain of sheep for maximum production of lambs and wool under farm conditions	Beltsville, Md. Middlebury, Vt.	G.M.Sidwell & C.E.Terrill	Yes	14-B-1
AH b1-4	Selecting and crossbreeding of Merino sheep for increased productivity**	Beltsville, Md.	G.M.Sidwell & C.E.Terrill	No	
AH b1-5	Investigations of systems of breeding for improvement of range sheep	Dubois, Idaho, Bozeman, Mont., Farson, Wyo.	S.K.Ercanbrack & R.L.Blackwell	Yes	14-A-1 14-B-3, 4
AH b1-6	Investigations of traits for use in breeding and selecting of range sheep	Bozeman, Mont.	S.K.Ercanbrack & R.L.Blackwell	Yes	14-A-1 14-B-3
AH b1-7	Studies in physiology of reproduction of range sheep	Dubois, Idaho	C.V.Hulet & R.L.Blackwell	Yes	15-A-1, 2, 3, 4, 5
AH b1-8	The occurrence of estrus in sheep as related to reproductive performance	Beltsville, Md.	G.M.Sidwell & C.E.Terrill	Yes	15-A-7
AH b1-10	Improvement of Navajo sheep by line breeding and selection within the Navajo strain **	Ft.Wingate, N.M.	R.D.Humphrey	Yes	14-A-2 16-A-2 22-B-2
AH b1-11	Improvement of fine wool sheep under Southwest conditions	Ft.Wingate, N.M.	R.D.Humphrey, T.D. Hall, & E.E.Ray	Yes	14-A-2, 3 16-A-2 22-B-2
AH b1-12	Improvement of coarse wool sheep production of wool suitable for Navajo hand weaving	Ft.Wingate, N.M. University Park, N.M.	R.D.Humphrey, T.D.Hall, and E.E.Ray	Yes	14-A-2, 3 16-A-2 22-B-2
AH b1-13	Influence of breeding on efficiency of gains in range sheep	Dubois, Idaho	K.R.Frederiksen, D.A.Price, and R.L.Blackwell	No	
AH b1-14	Testing of inbred lines of sheep	Dubois, Idaho, Beaconsfield, Ia., Bozeman, Mont., Prosser, Washington	S.K.Ercanbrack & R.L.Blackwell	Yes	14-B-4
AH b1-16	Improvement of commercial range sheep through breeding and selection	LaSal, Utah, Logan, Utah, & Ft.Collins, Colo.	G.M.Sidwell, T.H.Hall, M.A.Madsen	No	
AH b1-17	Development by selective breeding of a strain of sheep which will reproduce more often than once a year and without seasonal restrictions	Beltsville, Md.	G.M.Sidwell, C.E.Terrill & I.L.Lindhahl	Yes	14-B-2
AH b2	Sheep feeding investigations				
AH b2-1	The cause and prevention of urinary calculi in fattening beef cattle and sheep (See AH d2-31)	College Sta. & Big Springs, Texas	H.R.Crookshank & I.L.Lindhahl	Yes	16-A-1
AH b2-5	Factors in the utilization of pelleted feeds by sheep	Beltsville, Md. Newark, Dela.	I.L.Lindhahl P.J.Reynolds	Yes	16-A-2
AH b2-6	Investigations of physiological reactions of sheep and other ruminants in relation to metabolic disorders	Beltsville, Md.	I.L.Lindhahl	No	
AH b2-7	Investigations on the utilization of forage by sheep	Beltsville, Md. Newark, Dela.	I.L.Lindhahl & P.J.Reynolds	Yes	16-A-2, 3 16-B-1



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				Summary of Progress	Area & Subheading
AH b3	Sheep management investigations				
AH b3-1	Investigations of sheep grazing management on ranges of the Intermountain region	Dubois, Idaho	D.A.Price & R.L.Blackwell	Yes	16-C-1
AH b3-4	The response of Targhee sheep to different environments	Dubois, Idaho Ft. Wingate, N.M. Spooner, Wisc. & Beltsville, Md.	C.E. Terrill	No	
AH b3-5	The effect of shearing, light and season on rate of wool growth	Beltsville, Md.	M.E. Hourihan & C.E. Terrill	No.	
AH b3-7	Methods of producing milk fat lambs	Ft. Reno, Okla.	J.V. Whiteman, Jr. I.L. Lindahl, & C.E. Terrill	Yes	15-A-6 16-A-2 22-B-4
AH b3-8	Influence of environment at different geographic locations on fleece and body traits of sheep	Beltsville, Md.	C.E. Terrill	No	
AH b3-9	Investigations of the nutrition and management of range sheep	Dubois, Idaho	D.A. Price & R.L. Blackwell	Yes	16-A-3 16-D-1
AH b3-10	Comparative productivity of pastures grazed by beef cattle alone, sheep alone, and the two species in combination	Beltsville, Md.	I.L. Lindahl & P.J. Reynolds	No	
AH b3-11	Influence of management practices on internal parasitism of lambs	Beltsville, Md.	I.L. Lindahl & C.E. Terrill	Yes	16-D-2
AH b3-12	Fetal electrocardiography in livestock	Beltsville, Md.	I.L. Lindahl	Yes	15-A-3
AH b4	Goat nutrition investigations				
AH b4-3	Investigations of dairy goat production	Beltsville, Md.	I.L. Lindahl	Yes	15-A-3
AH b5	Investigations of wool and other animal fibers				
AH b5-1	Growth and development of the skin, fibers, and accessory follicular structures in goats **	Beltsville, Md.	E.H. Dolnick &	No	
AH b5-2	Factors affecting quality and value of wool	Dubois, Idaho, & Beltsville, Md.	L.O. Wilson, R.L. Blackwell, M.E. Hourihan, C.E. Terrill	Yes	22-E-1
AH b5-3(C)	Evaluation of wool from farm sheep breeding, nutrition, and management studies	Beltsville, Md., & Knoxville, Tennessee	M.E. Hourihan & C.E. Terrill	Yes	22-E-2
AH b5-5	Influence of age and season on the skin and follicular structures associated with shedding in Angora goats **	Beltsville, Md.	E.H. Dolnick & L.M. Hansen	No	
AH b5-6	Investigations of wool for the improvement of Navajo, Navajo crossbred, Targhee, and Targhee crossbred sheep under Southwest range conditions **	Ft. Wingate, N.M.	R.D. Humphrey & T.H. Hall	No	
AH b5-7	Relationships of fleece traits to measurable characteristics of card sliver, top, and noils from sheep of known genetic origin	Beltsville, Md. Dubois, Idaho	M.E. Hourihan C.E. Terrill, L.O. Wilson, & R.L. Blackwell	Yes	22-E-3
AH b6	Mutton, lamb and chevon studies				
AH b6-1	Meat characteristics of carcasses of lambs representing certain breeds and crosses	Beltsville, Md.	R.L. Hiner	Yes	22-B-1, 3

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				Summary of Progress (Yes-No)	Area & Subheading
AH d1	Beef Cattle Breeding Investigations				
AH d1-1 (rev. #2)	Breed crossing for increased production in beef cattle.	Miles City, Mont. Ft. Collins, Colo.	O. F. Pahnish	Yes	2-A-2 2-B-1
AH d1-2 (rev. #2)	Development of superior lines of beef cattle.	Miles City, Mont. Ft. Collins, Colo.	O. F. Pahnish	Yes	2-A-3
AH d1-5 (rev. #2)	Selection of cattle adapted to beef production in the Southeastern United States.	Brooksville, Fla.	W. C. Burns	No	
AH d1-6 (rev. #2)	Selection for changes in leanness in beef cattle and a study of the response to selection for adaptability in the Gulf Coast area.	Jeanerette, La.	T. M. DeRouen D. C. Meyer-hoeffer	Yes	3-A-5
AH d1-7 (rev. #2)	Heterosis from crosses among British breeds of beef cattle.	Blacksburg and Steel's Tavern, Va.	J. A. Gaines	Yes	2-A-2
AH d1-9 (rev. #2)	The improvement of producing ability of beef cattle.	Knoxville, Tenn.	C. S. Hobbs R. S. Temple	Yes	2-B-1
AH d1-16 (rev. #2)	A study of selection, inbreeding, and crossing of inbred lines within the Hereford breed.	Ft. Collins, Colo. Ft. Lewis, Colo.	H. H. Stonaker	Yes	2-A-3 2-C-1
AH d1-19 (rev. #2)	Diallel crossing in beef cattle and its use in breed improvement.	Corvallis, Oreg.	Ralph Bogart	Yes	2-A-3
AH d1-22 (rev.)	The improvement of production and adaptation of beef cattle within purebreeds and certain of their crosses through breeding methods.**	College Station, Tex.	T. C. Cartwright	No	
AH d1-23 (rev. #2)	Genetic and environmental interactions for performance and carcass traits in beef cattle.	Raleigh, Butner, Plymouth, and Laurel Springs, N. C.	E. U. Dillard	No	
AH d1-30 (rev.)	Improvement of reproductive performance in beef cattle.	Jeanerette, La.	W. L. Reynolds	Yes	3-A-5
AH d1-31 (rev.)	Effectiveness of selection for productive efficiency and carcass merit and the development of techniques for the identification of dwarfism carriers in beef cattle.	El Reno and Stillwater, Okla.	K. E. Gregory D. F. Stephens E. J. Turman	Yes	2-B-1,2
AH d1-32 (rev.)	Genetic-environmental influences on production and carcass traits in beef cattle.	Beltsville, Md.	E. J. Warwick	Yes	2-B-1
AH d1-33 (rev.)	Increasing reproductive efficiency in range beef cattle.	Miles City, Mont.	R. A. Bellows	Yes	3-A-2,3,4,5



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				Summary of Progress (Yes-No)	Area & Subheading
AH d1-34 (rev.)	Biochemical and cytological investigations of inherited dwarfism in beef cattle.	Gainesville, Fla.	Marvin Koger R. S. Temple	No	
AH d1-36 (rev.)	Interactions between genotype and environment in selection for economically important traits in Hereford cattle.	Reno, Nev., and Branch Stations	C. M. Bailey	Yes	2-B-1
AH d1-37 (rev.)	Improvement of reproductive performance in beef cattle.	Ft. Robinson, Nebr.	J. N. Wiltbank	Yes	3-A,1,2,4,5
AH d1-40 (rev.)	Studies of heterotic effects in crosses of the Angus, Hereford, and Shorthorn breeds of cattle.	Davis, Calif.	W. C. Rollins	Yes	2-A-2
AH d1-41	A study of response to selection and genetic-environmental interaction in genetically similar groups of Hereford cattle at two locations.	Miles City, Mont. Brooksville, Fla.	E. J. Warwick	Yes	2-C-2
AH d1-42	Heterosis in beef cattle.	Spickard, Mo.	J. F. Lasley	Yes	2-A-2
AH d1-43	Genetic and environmental influences on traits of economic value in beef cattle.	Madison, Wisc.	E. R. Hauser	Yes	2-B-4
AH d1-44	Basic population aspects of qualitative and cytological characters of beef cattle.	College Station, Texas	T. C. Cartwright	No	
AH d1-45	Relationships of beef and dairy characters in Milking Shorthorn cattle.	Rosemount and St. Paul, Minn.	C. L. Cole R. D. Plowman E. J. Warwick	No	
AH d1-46	Breeding and selection of beef cattle for the Southwest.	Tucson and San Carlos, Ariz.	C. B. Roubicek	No	
AH d1-47	The development of more efficient beef cattle for Georgia through the use of selection, progeny testing, inbreeding and crossbreeding.*	Tifton and Reidsville, Ga.	B. L. Southwell W. C. McCormick	No	
AH d1-48	The improvement of beef cattle for Virginia through breeding methods.*	Front Royal, Va.	B. M. Priode	Yes	2-A-1 3-A-1
AH d1-49	The effectiveness of inbreeding and selection in the improvement of performance of beef cattle.*	Brookings, S. Dakota	C. A. Dinkel	Yes	2-A-3 2-B-1
AH d1-50	The improvement of beef cattle through breeding methods.*	Ames, Iowa	L. N. Hazel E. A. Kline L. E. Johnston Garold Parks	Yes	2-A-2 2-B-1 2-C-1

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				Summary of Progress (Yes-No)	Area & Subheading
AH d1-51	Effectiveness of selection for productive efficiency and carcass merit, and the importance of heterosis in beef cattle.*	Ft. Robinson and Lincoln, Nebr.	K. E. Gregory R. M. Koch J. E. Ingalls	Yes	2-A-1,2 2-B-1
AH d1-52 (CA)	The heritability of various components of serum lipids and their relationship to the composition and distribution of fat in beef cattle.*	Ft. Collins, Colo.	D. A. Cramer	Yes	2-C-1
AH d1-53 (CA)	Genetics of certain protein components in milk from beef cows.*	Miles City and Bozeman, Mont.	A. E. Flower	No	
AH d2	Beef Cattle Nutrition Investigations				
AH d2-11 (rev.)	The effect of interrupted growth on the efficiency of beef production.**	Beltsville, Md.	P. A. Putnam	No	
AH d2-14 (rev.#2)	Nutritive value of feeds and forages as influenced by lignin, cellulose and other feedstuff components.	Beltsville, Md.	P. A. Putnam	No	
AH d2-21 (rev.)	Management and feeding practices affecting the gains of beef cattle on range and in the feedlot.	Ft. Robinson, Nebr.	J. E. Ingalls	No	
AH d2-22 (rev.)	Determination of the relation between protein and energy deficiencies and reproduction ability of beef cattle.	Beltsville, Md.	J. Bond	Yes	4-B-1
AH d2-26 (rev.)	Studies on the nutritional relationships between the ruminal protozoa and bacteria and their contribution to digestion in cattle and other ruminants.	Beltsville, Md.	L. L. Slyter R. E. Davis	Yes	4-A-5
AH d2-31	The cause and prevention of urinary calculi in fattening beef cattle and sheep.	College Station, Tex.	H. R. Crook-shank I. L. Lindahl	Yes	4-A-3 16-A-1
AH d2-32	Investigations of residues of new pesticides when ingested by beef cattle.	Beltsville, Md. Tifton, Ga.	B. L. Southwell	Yes	4-A-4
AH d2-34	Evaluation of pastures and forages in the Gulf Coast area in terms of reproductive performance by beef cattle.	Jeanerette, La.	W. L. Reynolds	Yes	3-A-1 4-F
AH d2-35	The interaction of nutrition and management in the growth and development of beef cattle.	Newell, S. Dak.	J. A. Minyard	Yes	4-A-3 4-F
AH d2-36	Growth, development, and reproductive performance of heifers and cows under different winter feeding treatments.	Ft. Reno, Okla.	D. F. Stephens	Yes	4-E-1



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				Summary of Progress (Yes-No)	Area & Subheading
AH d2-37	The relation of basic ration components and physical state of feeds to their feeding value.	Beltsville, Md. Ft. Reno, Okla.	P. A. Putnam R. R. Oltjen D. F. Stephens	Yes	4-A-1,2 4-B-1 4-C-1
AH d2-38 (c)	Factors affecting the utilization of corn, milo, barley and wheat in rations of beef cattle.	Davis, Calif.	G. D. Lofgreen	Yes	4-C-1
AH d2-39 (c)	A study of relative significance of ruminal and post-ruminal digestion of starch by beef cattle.	Lexington, Ky.	G. E. Mitchell	Yes	4-C-1
AH d2-40 (c)	Formulation of supplements to control feed intake of beef cattle.	Gainesville, Fla.	J. F. Hentges, Jr.	Yes	4-G-2
AH d2-41 (c)	Endocrine function and energy retention of the post-partum beef female as influenced by pre-partum energy intake.	Lincoln, Nebr.	D. R. Zimmerman	No	
AH d2-42	Nutritive evaluation of forages for beef production in the Coastal Plain region.	Tifton, Reidsville and Alapaha, Ga. Beltsville, Md.	B. L. Southwell	Yes	4-D-1 4-F
AH d2-43	Investigations of pesticide residues ingested by finishing and reproducing beef cattle.	Front Royal and Blacksburg, Va.	K. P. Bovard	Yes	4-A-4
AH d2-44	Investigations of location and concentration of residues of pesticides in beef cattle.*	Beltsville, Md.	T. S. Rumsey P. A. Putnam R. E. Davis	Yes	4-A-4
AH d2-45 (CA)	Effects of organic phosphate systemic insecticides on embryonic survival and development in the bovine.*	Miles City and Bozeman, Mont. Lincoln and Ft. Robinson, Nebr.	P. A. Putnam	No	
AH d3	Beef and Dual-Purpose Cattle Management Investigations				
AH d3-1 (rev. #2)	Sustained beef cattle production and maintenance of range quality in the Northern Great Plains by the use of supplemental spring pastures.	Beltsville, Md. Miles City, Mont.	J. J. Urick	Yes	3-A-1 4-E-1
AH d3-2 (rev.)	Management of cattle and pastures for beef production.	Brooksville and Gainesville, Fla. Knoxville, Tenn. Beltsville, Md.	W. C. Burns	Yes	3-A-1 4-E-1
AH d3-3 (rev. #2)	Improving herd management on forest range.	Tifton, Ga. Beltsville, Md.	B. L. Southwell	No	
AH d3-4	Integration of livestock and timber production on intensively managed pastures.	Tifton, Ga. Beltsville, Md.	B. L. Southwell	No	

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				Summary of Progress (Yes-No)	Area & Subheading
AH d3-6	The comparisons of the production of beef from beef, dual purpose and dairy steers.**	Beltsville, Md.	E. J. Warwick R. E. Davis J. Bond J. W. Thomas N. W. Hooven, Jr. R. L. Hiner	Yes	5-A-5
AH d3-7	Effects of management and growth variables on performance and carcass merit in beef cattle.	Beltsville, Md. Ft. Reno and Stillwater, Okla.	D. F. Stephens	Yes	4-E
AH d3-8	Use of supplementary nonprotein nitrogen and nonedible protein in the management of cattle and pastures for beef production.*	Brooksville, Fla. Ft. Reno, Okla. Beltsville, Md.	W. C. Burns	No	
AH d4-7	Meat characteristics of carcasses of beef developed through breeding, nutrition and management.	Beltsville, Md.	R. L. Hiner	No	

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				Summary of Progress	Area & Subheading
AH e1	Poultry breeding investigations				
AH e1-43 (C)(Rev.)	Evaluation of breeding systems for chickens.	Lafayette, Ind. & 8 North Central State Experiment Stations	T. B. Kinney & Cooperators	Yes	9-B-1,2
AH e1-44 (Rev.)	Development and evaluation of breeding techniques in chickens.	Athens, Ga., & 14 Southern State Experiment Stations	L. D. Tindell & Cooperators	Yes	9-A-5 9-B-2
AH e1-47	Avian reproduction under subcircadian periodicities.	Beltsville, Md.	H. L. Marks	Yes	9-A-2
AH e1-48	Genetic aspects of the ability of chickens to utilize amino acids.	Beltsville, Md.	S. P. Wilson	No	
AH e1-49	Genetic aspects of feed utilization in the chicken.	Beltsville, Md.	S. P. Wilson	No	
AH e1-50	Breeding chickens for resistance to gonadotropic hormone inhibition.**	Beltsville, Md.	S. P. Wilson	No	
AH e1-51	Performance of fowl as influenced by physiological traits and pleiotropic genes.	Eight North-eastern State Experiment Stations	S. P. Wilson & Cooperators	No	
AH e1-52	Biochemical basis for genetic differences in growth rate.	Beltsville, Md.	P. D. Lepore	Yes	9-A-1
AH e1-53	Selection for hatchability of turkey eggs at different altitudes.	Three Western State Experiment Stations	S. P. Wilson & Cooperators	No	
AH e1-54	Effect of interspecies blood injections on heritable traits of the domestic fowl.*	Lafayette, Ind.	T. B. Kinney & P. C. Lowe	No	
AH e1-55	Identification of specific genotype-environment interactions in commercial egg production stocks.*	Athens, Ga.	L. D. Tindell	No	
AH e1-56	Cytogenetic studies with avian species.*	Beltsville, Md.	P. A. Sarvella	Yes	9-A-4
AH e2	Poultry nutrition investigations				
AH e2-15 (Rev.)	Effect of high air temperatures on optimum levels of nutrients in diets of chickens.	Glendale, Arizona	B. W. Heywang	Yes	11-C-2
AH e2-16	Protein-amino acid requirements of chickens and turkeys.**	Beltsville, Md.	R. J. Lillie	No	
AH e2-17 (Rev.)	Levels of toxic cottonseed constituents in poultry diets that affect growth, egg production and egg quality.	Glendale, Arizona	B. W. Heywang	Yes	11-C-1
AH e2-18	Mineral requirements of poultry.**	Beltsville, Md.	C. A. Denton & R. J. Lillie	No	
AH e2-19 (C)	Malathion residues in poultry meat and eggs.	Ames, Iowa	C. A. Denton	No	
AH e2-20	Energy and fatty acids in poultry nutrition.	Beltsville, Md.	H. Menge & C. C. Calvert	Yes	11-A 11-B-1
AH e2-21	DDT residues in eggs and body tissues of hens.*	Athens, Ga.	C. A. Denton	No	

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				Summary of Progress	Area & Subheading
AH e3	Poultry physiology investigations				
AH e3-18	Effects of environmental variables on reproduction in turkeys.	Beltsville, Md.	S. J. Marsden & R. M. Fraps	No	
AH e3-19	Parthenogenesis in avian eggs.	Beltsville, Md.	M. W. Olsen, H. K. Poole & R. M. Fraps	Yes	10-A-2
AH e3-20	The homograft reaction and immunological tolerance in birds.	Beltsville, Md.	H. K. Poole, M. W. Olsen & R. M. Fraps	No	
AH e3-21	Mechanisms controlling oviposition and ovulation in birds.	Beltsville, Md.	H. Opel & R. M. Fraps	Yes	10-A-1
AH e3-22	Pituitary-ovarian relationships controlling egg production in the Coturnix quail.	Beltsville, Md.	H. Opel & R. M. Fraps	No	
AH e3-23	The effects of controlled photo-periods and light intensity on growth and egg production of chickens.	Glendale, Arizona	R. W. Lowe & B. W. Heywang	Yes	10-B-1
AH e3-24	The effect of various densities on egg production and mortality in caged and floor housed pullets.	Glendale, Arizona	R. W. Lowe & B. W. Heywang	Yes	10-B-2
AH e3-25	Control of eggshell pigmentation in Japanese quail.	Beltsville, Md.	H. K. Poole & R. M. Fraps	Yes	10-A-3
AH e4	Poultry meat and egg quality as affected by nutrition, breeding, physiology and other management factors				
AH e4-11	The effect of hen's age, season, environmental temperature and on-farm holding conditions on egg quality.	Glendale, Arizona	R. W. Lowe & B. W. Heywang	No	
AH e4-12	Influence of environmental factors on poultry products.	Beltsville, Md.	E. H. McNally & C. W. Hess	No	
AH e5	National Poultry and Turkey Improvement Plans  (There are no line projects under this Work Project).	Beltsville, Md., in cooperation with 47 official State Agencies (Alaska, Hawaii and Nevada not included)	S. A. Moore & R. D. Schar	Yes	21-B-1,2
AH e6	Improvement of viability of poultry				
AH e6-2 (Rev. #2)	The development and maintenance of in-bred lines of chickens showing a wide range of resistance and susceptibility to avian lymphomatosis.	East Lansing, Mich.	L. B. Crittenden	Yes	12-D
AH e6-3 (Rev. #2)	The production and maintenance of susceptible chickens free of lymphomatosis.	East Lansing, Mich.	L. B. Crittenden, J. J. Solomon & B. R. Burmester	Yes	12-C
AH e6-17 (Rev. #2)	Studies on the immunity of chickens to avian tumor viruses.	East Lansing, Mich.	W. Okazaki	No	



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				Summary of Progress	Area & Subheading
AH e6-24 (Rev.)	Studies of the chicken tumor viruses <u>in vitro</u> .	East Lansing, Mich.	J. J. Solomon & B. R. Burmester	No	
AH e6-27	Studies on the epizootiology of avian lymphomatosis and related neoplasms.	Michigan, Ind., N. Jersey & Israel	B. R. Burmester	Yes	12-C
AH e6-28	A study of the genetic variability remaining in highly inbred lines of chickens.	East Lansing, Mich.	L. B. Crittenden	Yes	12-D
AH e6-29 (C)(Rev.)	A study of genetic resistance and susceptibility to virus induced neoplasms of chickens.	East Lansing, Mich. & N. York	L. B. Crittenden, W. Okazaki & H. G. Purchase	Yes	12-D
AH e6-30 (C)	Studies on the etiology of the acute lymphomatosis syndrome.	East Lansing, Mich., Ga. & Connecticut	R. L. Witter & B. R. Burmester	Yes	12-A
AH e6-31	Studies of host-cell oncogenic virus relationship.	East Lansing, Mich.	R. W. Hinz & B. R. Burmester	No	
AHe6-32	Antigenic and host range characterization of the avian tumor viruses.	East Lansing, Mich.	W. Okazaki & L. B. Crittenden	Yes	12-B
AH e6-33	Studies on the role of the lymphoid organs in the pathogenesis of the neoplasms of the avian leukosis complex.	East Lansing, Mich.	H. G. Purchase & B. R. Burmester	Yes	12-A-1
AH e6-34	Maintenance of genetic lines of chickens free of diseases of the avian leukosis complex (ALC) and other specific infectious and parasitic diseases.*	East Lansing, Mich.	P. A. Long, R. L. Witter, L. B. Crittenden & B. R. Burmester	No	
AH e7	Relation of management and genetics to broiler losses				
AH e7-1	Factors influencing airsacculitis and condemnations in broilers.	State College, Miss.	R. T. Parkhurst	No	
AH e7-2	Genetic aspects of resistance and susceptibility of chickens to Newcastle disease virus.	Athens, Ga.	C. D. Gordon	Yes	13-A
AH e7-3	Response of chickens to hormonal and environmental stimuli.	Athens, Ga.	H. S. Siegel	Yes	13-B
AH e7-4	Management factors influencing airsacculitis and condemnation in broilers.	State College, Miss.	R. T. Parkhurst & J. W. Deaton	Yes	13-B
AH e8	Avian anatomy investigations				
AH e8-1	Skeletal and muscular systems of domesticated and laboratory birds.	East Lansing, Mich.	A. M. Lucas	Yes	1-B

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				Summary of Progress	Area & Subheading
AH f1	Fur animal breeding				
AH f1-1	Genetic investigations of traits for use in breeding and selection for improvement of meat rabbits **	Fontana, and Davis, Calif.	R.B.Casady	No	
AH f1-2	Genetics of mink and marten with emphasis on mutant characters and pelt quality	Madison, Wisc.	R.M.Shackelford	Yes	20-A-1, 2
AH f1-3	Development of a superior strain of silver foxes	Petersburg, Alaska	J.R.Leekley	No	
AH f1-4	Marten mating systems to increase breeding regularity and prolificacy	Petersburg, Alaska	J.R.Leekley	Yes	20-B-4
AH f1-6	Effect of breeding does at various intervals following kindling on the growth and weaning weight of the young and on reproductive performance of the doe **	Fontana,	R.B.Casady	No	
AH f1-7	Investigations of spontaneous glaucoma in rabbits **	Fontana, Calif.	R.B.Casady	No	
AH f2	Fur animal physiology of reproduction				
AH f2-1	Effect of hormones on growth and reproduction of mink	Ithaca, N.Y. Madison, Wisc. Swarthmore, Pa.	H.F.Travis, R.M.Shackelford R.K.Enders	Yes	20-B-1, 3
AH f2-5	Investigation of fetal development and fetal anomalies in rabbits **	Fontana, Calif.	R.B.Casady	No	
AH f2-6	Effects of DDT on reproductive performance and growth of mink *	Ithaca, N.Y. Beltsville, Md.	H.F.Travis C.E.Terrill	Yes	20-B-2
AH f3	Fur animal feeding and nutrition				
AH f3-1	Development of diets based on ocean and fresh water fish and sea mammals and their products for blue fox, mink and marten	Petersburg, Alaska	J.R. Leekley and C.A.Cabell	Yes	20-C-1
AH f3-2	Relationship of nutrient factors and physical characteristics in diet to rabbit production **	Fontana, Calif.	R.B.Casady	No	
AH f3-4	Study of various proteins as rabbit feed **	Fontana, Calif.	R.B.Casady	No	
AH f3-5	Investigation of the basic nutrient requirements and nutrient utilization by mink	Ithaca, N.Y.	H.F.Travis	Yes	20-C-2,3,4
AH f3-6	The development of practical diets and feeding practices for mink	Ithaca, N.Y.	H.F.Travis.	No	
AH f4	Fur fiber and fur investigations				
AH f4-3	The priming process in fur bearing animals	Beltsville, Md.	E.H.Dolnick	Yes	20-B-5
AH f4-4	Influence of endocrine factors on the development of fur-bearing animals	Beltsville, Md.	E.H.Dolnick	No	

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				Summary of Progress	Area & Subheading
AH g1	Genetics and interrelations of anatomical and physiological characteristics of dairy cattle.				
AH g1-4 (Rev.)	Studies of the genetics of feed utilization in dairy cattle.	Beltsville, Md. Ithaca, N.Y. Lewisburg, Tenn. Jackson, Tenn. Bozeman, Mont. Logan, Utah	N.W. Hooven, Jr. R.D. Plowman G. W. Trimberger J. Owen B. Hazelwood J. Boyd R. Lamb	Yes	5-A-4
AH g1-5 (Rev.)	Studies of the genetics of milk composition and properties related to market acceptance.	Beltsville, Md. E.Lansing, Mich. Madison, Wisc.	C. A. Kiddy	Yes	5-A-6
AH g1-6 (Rev.)	A comparative study of genetic and seriological developments in cattle blood typing.	Beltsville, Md. & cooperating laboratories	C. A. Kiddy	Yes	5-A-7
AH g1-7 (Rev.)	The importance of immunogenetic factors in problems of lowered fertility in cattle.	Beltsville, Md.	C. A. Kiddy H. W. Hawk	Yes	5-A-10,11
AH g1-8	Antibodies in bovine milk.**	Beltsville, Md.	C. A. Kiddy R. D. Plowman W. D. Schultze	No	
AH g1-9 (C)	Development and evaluation of various methods of raising meat animals from dairy and beef calves.	Madison, Wisc.	R. D. Plowman E. J. Warwick	Yes	5-A-8
AH g2	The application of advanced genetic concepts and principles for the improvement of dairy cattle.				
AH g2-5 (Rev.)	Developing and evaluating desirable production characteristics in Holstein cattle by inbreeding, outbreeding and inter-line crossing.	Lake Mills, Wisc Madison, Wisc.	W. J. Tyler	Yes	5-B-1
AH g2-22 (Rev)	Estimation of the relative importance of general and specific combining ability in relation to breeding dairy cattle.	St.Paul, Minn. Columbus, Ohio	R. D. Plowman C. W. Young T. M. Ludwick	Yes	5-B-2
AH g2-23 (Rev)	Evaluation of interbreed matings as a genetic method for improving economically important traits in dairy cattle.	Beltsville, Md. Urbana, Ill. Lafayette, Ind.	R. E. McDowell R. W. Touchberry T. G. Martin	Yes	5-B-5a,b
AH g2-24 (Rev)	The influence of parental relationship on the genetic merit of dairy sires and cows.	Farmland, Ind. Beltsville, Md.	R. D. Plowman	Yes	5-B-3
AH g2-25 (Rev)	The value of continuous use of progeny tested sires and sons of progeny tested for improving dairy cattle.	Beltsville, Md.	R. D. Plowman	No	
AH g2-26 (Rev)	Comparisons of genetic methods of using sires available in artificial breeding of dairy cattle.	St.Paul, Minn.	C. W. Young	Yes	5-B-4
AH g2-28	A comparison of selection for milk production with selection for high protein percent in dairy cattle.	Cortland, N.Y.	C. R. Henderson	No	
AH g3	Investigations of dairy herd management.				

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				Summary of Progress	Area & Subheading
AH g3-8 (Rev.)	Evaluation of management practices for the control of bovine mastitis.	Beltsville, Md.	W. D. Schultze	Yes	8-A-1b,c
AH g3-10 (Rev.)	Electrically controlled and operated equipment for reduction of labor in dairy production.	Beltsville, Md. St. Paul, Minn.	R. D. Plowman	Yes	6-B-1 8-A-1a,2
AH g3-12 (Rev.)	Evaluation and development of equipment and physical methods for control of flies and other dairy cattle pests.	Beltsville, Md.	R. D. Plowman J. W. Smith	Yes	8-A-3
AH g3-13 (C)	Evaluation of mechanical sanitation as a means of reducing fly populations on dairy farmsteads.	Baton Rouge, La.	R. D. Plowman	Yes	8-A-3
AH g4	Factors influencing adaptability of dairy cattle to hot, humid conditions of the South.				
AH g4-1 (Rev.)	Relationship of anatomical and physiological characteristics to the adaptability of cattle.	Baton Rouge, La. Beltsville, Md.	J. E. Johnston R. E. McDowell	Yes	6-C-1,2,3 1-D-7,8
AH g4-2 (Rev.)	Systems of breeding for developing adaptability of dairy cattle to hot and/or humid climates.	Baton Rouge, La. Jeanerette, La. Reidsville, Ga. Tifton, Ga.	R. E. McDowell C. Branton B. Hollon J. C. Johnson	Yes	5-B-6a,b,c, d,e,f
AH g4-3 (Rev.)	The influence of management practices and other environmental factors on adaptability of dairy cattle to hot and humid regions.	Tifton, Ga. Baton Rouge, La. Jeanerette, La. Beltsville, Md.	J. C. Johnson J. E. Johnston B. Hollon R. E. McDowell	Yes	1-E-1,2
AH g5	Evaluation of concepts for procurement, interpretation and use of dairy herd records.				
AH g5-1	Studies on methods for minimizing environmental influences on production records of individual cows and progeny groups.	E. Lansing, Mich. Madison, Wisc. Beltsville, Md. College Pk., Md. Washington, D. C.	E. L. Corley	Yes	8-B-1,2
AH h1	The nutritional factors affecting normal growth and health of calves and growing cattle.				
AH h1-1 (Rev.)	Factors affecting the intake of hay crop silage by dairy heifers.	Beltsville, Md.	D. R. Waldo M. Okamoto R. W. Miller	Yes	7-C-1,2,3,4, 5,6
AH h1-5	The utilization of the carotene from corn silage by dairy calves.	Beltsville, Md.	R. W. Miller D. R. Waldo T. R. Wrenn L. A. Moore G. P. Lynch	Yes	7-C-7
AH h1-6 (C)	A study of factors affecting the development of fungal toxins in forages.*	Madison, Wisc.		No	
AH h2	A study of nutritional and related factors affecting the usefulness of producing dairy cattle.				
AH h2-3	Studies on the microbiology of bovine rumen.	Beltsville, Md.	K. A. Pittman	Yes	1-F-1,2,3
AH h2-5	Factors involved in the efficiency of forage utilization by dairy heifers.	Beltsville, Md.	D. R. Waldo G. F. Fries	No	
AH h2-6	Development and use of chemical methods for determining the nutritive value of dairy feeds and forages.	Beltsville, Md.	P. J. VanSoest R. Wine	Yes	7-A-7a,b,c,d e

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				Summary of Progress	Area & Subheading
AH h2-7	The measurement of heat production of grazing cattle.**	Beltsville, Md.	D. R. Waldo	No	
AH h2-8	Determination of the nutritive value of cattle feeds by calorimetric methods.	Beltsville, Md.	W. P. Flatt	Yes	7-A-1,2,3,4,5,7
AH h2-10 (C)	Study of the metabolism and excretion of ingested radionuclides in relation to nutrition and health of farm animals and to the accumulation of radionuclides in animal food products.	Ithaca, N.Y.	P. W. Moe C. L. Comar G. F. Fries	No	
AH h2-11	A study of the efficiency of use of metabolizable energy for growth of dairy cattle.	Beltsville, Md.	L. A. Moore	No	
AH h2-12 (C)	Effects of liberal concentrate feeding on health, reproductive efficiency, milk production, economy of milk production and other related responses.	Ithaca, N.Y. Beltsville, Md.	J. K. Loosli L. A. Moore	No	
AH h2-13 (C)	Factors affecting the absorption and excretion of Heptachlor Epoxide by dairy animals.	College Pk., Md.	R. F. Davis R. L. King R. W. Hempken C. H. Gordon J. C. Derbyshire	No	
AH h2-14	Pesticide residues in the tissues and milk of dairy cattle.	Beltsville, Md. Tifton, Ga.	L. A. Moore L. A. Moore C. H. Gordon J. C. Derbyshire	Yes	7-D-1,2,3,4
AH h3	Studies on management, preservation and utilization of grassland crops for dairy cattle.				
AH h3-1	A biochemical study of the ensiling of forage crops.**	Beltsville, Md.	C. H. Gordon	No	
AH h3-3	A study of the effects of kinds of crop, kinds of treatment, methods of handling and conditions of storage of forage on the resulting silages and the production of silages suitable for fundamental bacteriological and biochemical studies.	Beltsville, Md.	C. H. Gordon J. C. Derbyshire L. A. Moore	Yes	7-B-1,2,3,4,5,6,7
AH h3-12 (Rev.)	Value of grazing pasture forage as compared to harvesting as silage for dairy cattle.	Lewisburg, Tenn.	D. R. Waldo J. Owen	Yes	7-B-8,9,10
AH h3-17 (Rev.)	The relation of date of cutting and dry matter content when cut to digestibility, consumption and acre nutrient yields of forage crops.	Logan, Utah	D. R. Waldo M. J. Anderson G. E. Stoddard	No	
AH h3-18	The effect of varying stocking rates on nutrient yields per acre of orchard-grass-ladino clover pastures and on production per animal.**	Beltsville, Md.	C. H. Gordon J. C. Derbyshire	No	
AH h3-19	Concentrate supplementation responses of dairy cows on pasture and dry lot rations.	Logan, Utah Beltsville, Md.	M. J. Anderson D. R. Waldo	No	

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				Summary of Progress	Area & Subheading
AH h3-20 (C)	The effects of variety, selection and production methods of corn on the cost and feeding value of corn silage for dairy cattle.	College Pk., Md.	C. H. Gordon	No	
AH h4	Bioassay of nutritional requirements and processes of dairy cattle.				
AH h4-3 (Rev.)	Relation of vitamin B <sub>12</sub> to ruminant metabolism.	Beltsville, Md.	A. M. Hartman L. P. Dryden	Yes	1-E-1,2
AH h5	Physiological studies of reproduction, mammary gland growth and lactation in dairy cattle.				
AH h5-1 (Rev.)	Biochemistry and physiology of mammary gland growth.	Beltsville, Md.	J. Bitman T. R. Wrenn	Yes	1-D-2
AH h5-2 (Rev.)	The determination of secretion rate and metabolism of hormones in dairy cattle as related to reproductive function.	Beltsville, Md.	J. Bitman	No	
Ah h5-6	Physiological bases for variations in fertilization success and embryo survival that may be associated with lowered fertility in cattle.	Madison, Wisc. Beltsville, Md.	L. E. Casida H. W. Hawk	Yes	1-D-1g 1-D-6b,c
AH h5-8	Endocrine influences on embryonic mortality and uterine physiology.	Beltsville, Md.	H. W. Hawk	Yes	1-D-1a,b,c, d,e,f 1-D-2,3,6a
AH h5-9	Physiological defensive mechanisms of the mammary gland as related to mastitis.	Beltsville, Md.	H. W. Hawk J. Bitman W. D. Schultze R. D. Plowman	No	
AH i4	Dairy herd improvement research through analyses of data collected in National Cooperative Dairy Herd Improvement and Sire-Proving Programs and the development of effective production testing organizations.				
AH i4-1	Research on the evaluation of superior sires and cows in the national dairy herd and on the factors affecting these estimations.	Beltsville, Md. New Orleans, La. Arlington, Va. Bethesda, Md.	E. L. Corley R. H. Miller B. T. McDaniel	Yes	21-A-1,2
AH i4-2	Analysis of different types of records of performance and breeding society organizations, testing plans, methods and forms used in collecting and evaluating production records to improve the effectiveness of DHIA sire-proving and related programs.	Beltsville, Md. New Orleans, La. Arlington, Va. Bethesda, Md.	E. L. Corley R. H. Miller B. T. McDaniel	Yes	21-A-3
AH i4-3	Analysis of DHIA cow and herd production records to determine from year to year the relationships between yield, feed inputs, costs and related factors.	Beltsville, Md. New Orleans, La. Arlington, Va.	E. L. Corley R. H. Miller B. T. McDaniel	Yes	21-A-4a,b,c, d,e,f,g,h,i, j,k,l
AH j1	Humane slaughter of meat animals.			No.	



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				Summary of Progress	Area & Subheading
AH k1	Basic metabolism, fate and role of agricultural chemicals ingested by livestock.				1-A-1,3
AH k1-1	The metabolic fate of insecticidal chemicals in livestock and poultry as related to residues in animal products.	Fargo, N.D.	E. J. Thacker	Yes	1-A-2,4
AH p1	Pioneering Blood Antigen Laboratory	Beltsville, Md.	S. L. Schein- berg	Yes	1-C-2a,b, c,d
AH p2	Methods and theories of population genetics.	Lafayette, Ind.	W. H. Kyle	Yes	1-C-1a,b

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				Summary of Progress	Area & Subheading
A7-AH-1	PL 480 Projects Physiology and genetics of characteristics influencing the adaptability of cattle and buffalo for dairy production in India; genetic methods for developing adaptability and the effect of climatic elements and other environmental influences on adaptability.	Izatnagar, India	G. Guha (R.E. McDowell)	Yes	6-C-7
A7-AH-6	Nutritional physiology of different breeds of Indian cattle.	Karnal, India	D. N. Mullick (R.E. McDowell)	Yes	6-C-6 8-B-3
A7-AH-11	Factors affecting the utilization of low-grade roughages and production of volatile fatty acids in the rumen of cattle.	Punjab, India	G. S. Sidhu (L. A. Moore)	Yes	7-C-5,6,8
A7-AH-15	Effectiveness of different methods of utilizing available sources of germ plasm in improving the productive performance of poultry.	Udaipur, India	U. V. Sharma (S. P. Wilson)	No	
A7-AH-18	Investigations on milk and meat potentialities of Indian goats.	Uttar Pradesh, India	S. N. Singh (I. L. Lindahl)	No	
A7-AH-21	Evaluation of feedstuffs available in India for protein quality and energy values.	Ludhiana, India	G. Sidhu (C. A. Denton)	Yes	11-C-3
A7-AH-23	Collection and evaluation of native fowl germ plasm.	India	Dalbir Singh	No	
A7-AH-33	Ovarian function and its experimental control in the water buffalo ( <i>Bos. bubalis</i> ).*	Anand, India	N. C. Buch (H. W. Hawk)	No	
A10-AH-2	Comparative studies of 'repeat breeders' and normal cows and heifers.	Beit Dagan, Israel	Nathan Ayalon (H. Hawk)	Yes	6-A-2
A10-AH-3	The mechanism of lactation and its augmentation by hypothalamic stimulation.	Jerusalem, Israel	F. G. Sulman (J. Bitman)	Yes	6-B-2
A10-AH-7	Utilization and function of vitamin A in nutrition of poultry.	Rehovot, Israel	A. Bondi (C. A. Denton)	Yes	11-B-3
A10-AH-8	Utilization of different kinds of protein feeds by ruminants.	Rehovot, Israel	A. Bondi (P.J. Reynolds)	Yes	16-A-2
A10-AH-9	The effect of X-rays on viability genes with special reference to their action in heterozygotes and to the mechanism of heterosis.	Jerusalem, Israel	Raphael Falk (S.L.Scheinberg)	No	
A10-AH-10	Liberal feeding of concentrates and reproductive management as a means of higher production.	Rehovot, Israel	J. Tennenbaum Kali (R. D. Plowman)	No	



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A10-AH-12	The separation of young and old spermatozoa.	Rehovot, Israel	R. Volcani (R. J. Gerrits)	Yes	1-D-11
A10-AH-13	Factors acting in long-term storage of sperm <u>in vivo</u> .	Rehovot, Israel	R. Volcani H. Schindler (R. J. Gerrits)	Yes	1-D-9,10
A10-AH-14	Bacteriological problems in artificial insemination of hens.	Israel	M. Perek (S. P. Wilson)	No	
A10-AH-16	Some aspects of the carbohydrate and fat economy of lactating sheep with particular reference to Ketosis.	Jerusalem, Israel	E. Wertheimer and J. Adler (I. L. Lindahl)	Yes	16-A-1
A10-AH-17	Water transport through animal membranes: Influence of the pH and the ionic composition of the bathing fluids on the effect of vasopressin.	Jerusalem, Israel	T. D. Ullman (J. Bitman)	Yes	1-D-5
A10-AH-18	The effectiveness of selection and various A. I. techniques in increasing the fertility of chickens inseminated with turkey semen.*	Rehovot, Israel	Morris Soller (Dr. Olsen)	No	
A10-AH-20	Studies on calcium and phosphorus metabolism in the chicken; investigation of the factors influencing egg shell quality.	Rehovot, Israel	Samuel Hurwitz (C. A. Denton)	Yes	11-B-2
A10-AH-24	Studies on Avian Leukosis (avian lymphomatosis).*	Ness-Ziona, Israel	Alexander Kohn (Dr. Burmester)	No	
A22-AH-2	White muscle disease of lambs in Turkey.	Ankara, Turkey	Cahit Ozcan (I. L. Lindahl)	Yes	16-A-1
E21-AH-1	Secretion of anterior pituitary hormones & ovulation in small ruminants.**	Jablonna, Poland	E. Domanski (J. Bitman)	Yes	1-D-4
E21-AH-2	Color in pork as influenced by heredity, sex, age, feeding & management of animals.**	Warsaw, Poland	M. A. Janicki (R. L. Hiner)	Yes	22-C-2
E21-AH-4	Investigations of blood groups in a new racial group of the "Zlotnicka Pig."	Poznan, Poland	Antonio Kaczmarek (C. M. Kincaid)	No	
E21-AH-5	Protein compounds of vitamin B <sub>12</sub> and its analogs.	Poznan, Poland	J. Janicki (A. M. Hartman)	No	
E21-AH-6	Trace element contents in forage crops in relation to the stage of development of the plants, method of gathering and storage.	Poznan, Poland	K. Gawecki (R. E. Davis)	Yes	4-F-1
E21-AH-7	The reactions in the guinea pig liver microsomes during the protein biosynthesis <u>in vitro</u> .	Warsaw, Poland	J. Heller P. Szafranski (R. Oltjen)	Yes	4-B-1
E21-AH-8	The influence of somatotrophin (STH-growth hormones) on fat metabolism in adult hens.	Warsaw, Poland	W. Herman (R. M. Fraps)	No	

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E21-AH-11	Physiological factors controlling the occurrence of pale, soft and exudative meat in pigs.*	Warsaw, Poland	Mieczystaw Janicki (R. L. Hiner)	No	
E25-AH-6	A pilot study with Tribolium of the influence of environmental stress on genetic parameters and response to selection.	Madrid, Spain	F. Orozco (S. P. Wilson)	No	
E30-AH-6	Protein metabolism in monogastric animals connected with their requirements for essential limited amino acids.*	Belgrade, Zemun, Yugoslavia	Darko Stosic (R. J. Davey)	No	
F4-AH-1	Improving and evaluating Fayoumi and Dandarawi fowls.	Dekki, Giza, Egypt	I. F. Sayed (S. P. Wilson)	No	
S3-AH-7	Structural and physiological characteristics associated with adaptability of cattle in tropical and sub-tropical areas.**	Pirassununga, Brazil	J. S. Veiga (R.E. McDowell)	Yes	6-C-4,5
S5-AH-1	Evaluation of the native breed, Costeno con Cuernos, and European breeds and European-native breed crosses when managed and selected for dairy cattle traits under the hot and humid conditions of Northern Colombia.	Turipana, Colombia	R. K. Waugh (R.E. McDowell)	Yes	5-B-6-g
S9-AH-1	The nutritional value of the fish silage produced by yeasts fermentation for animal feeding.	Montevideo, Uruguay	Victor H. Bertullo (C. A. Cabell)	Yes	1-E-3

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